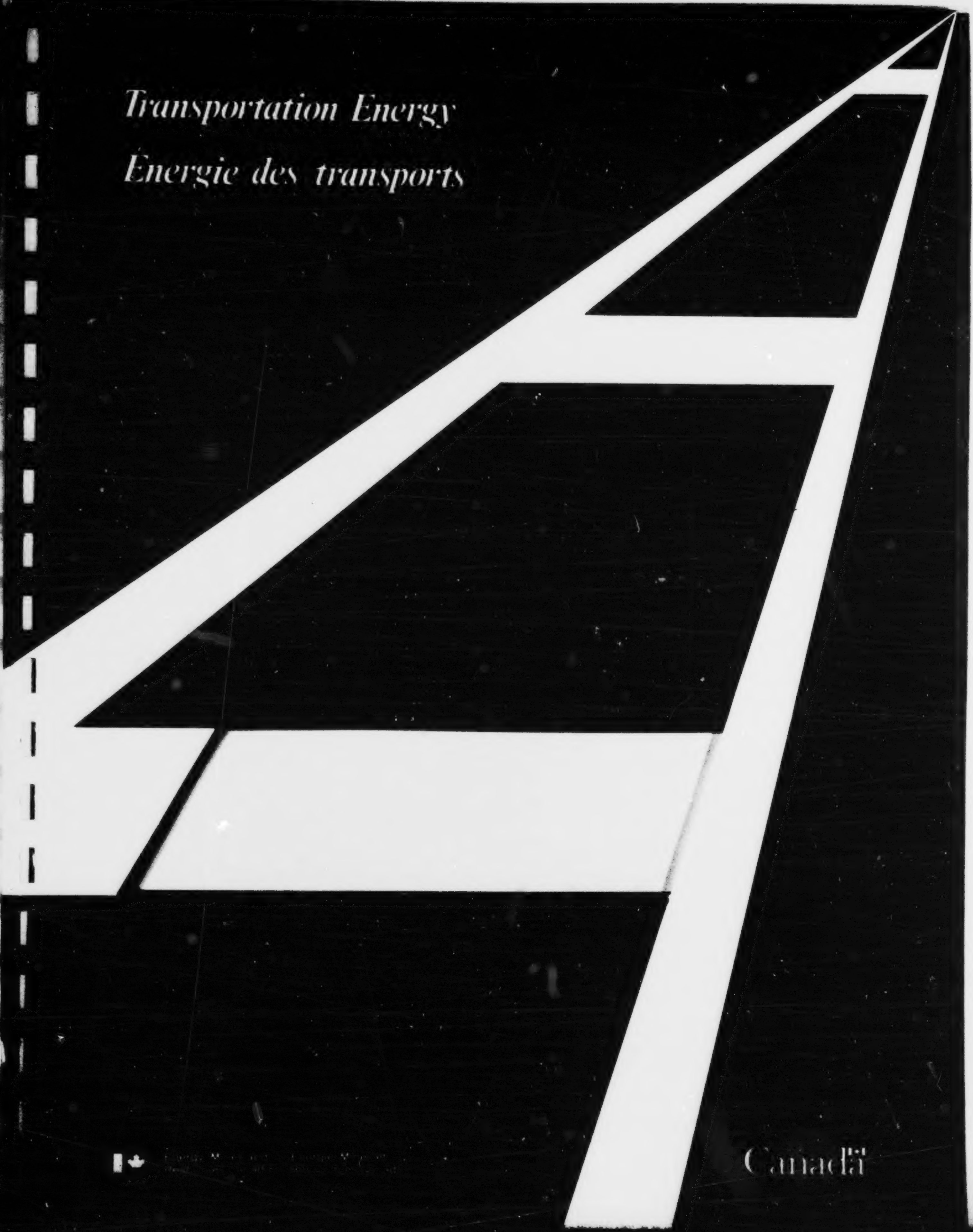
Transportation Energy

Énergie des transports



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Canada

FINAL REPORT
NATURAL GAS VEHICLE
FUEL

KAMLOOPS DEMONSTRATION PROJECT

TE-86-1

DISCLAIMER

This study was carried out with the cooperation of the Department of Energy, Mines and Resources. However, the views expressed in the report are those of the author and do not necessarily reflect the views of the Department.

FINAL REPORT

NATURAL GAS VEHICLE FUEL
KAMLOOPS DEMONSTRATION PROJECT

PREPARED FOR

ENERGY, MINES, AND RESOURCES CANADA

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1066 WEST HASTINGS STREET,
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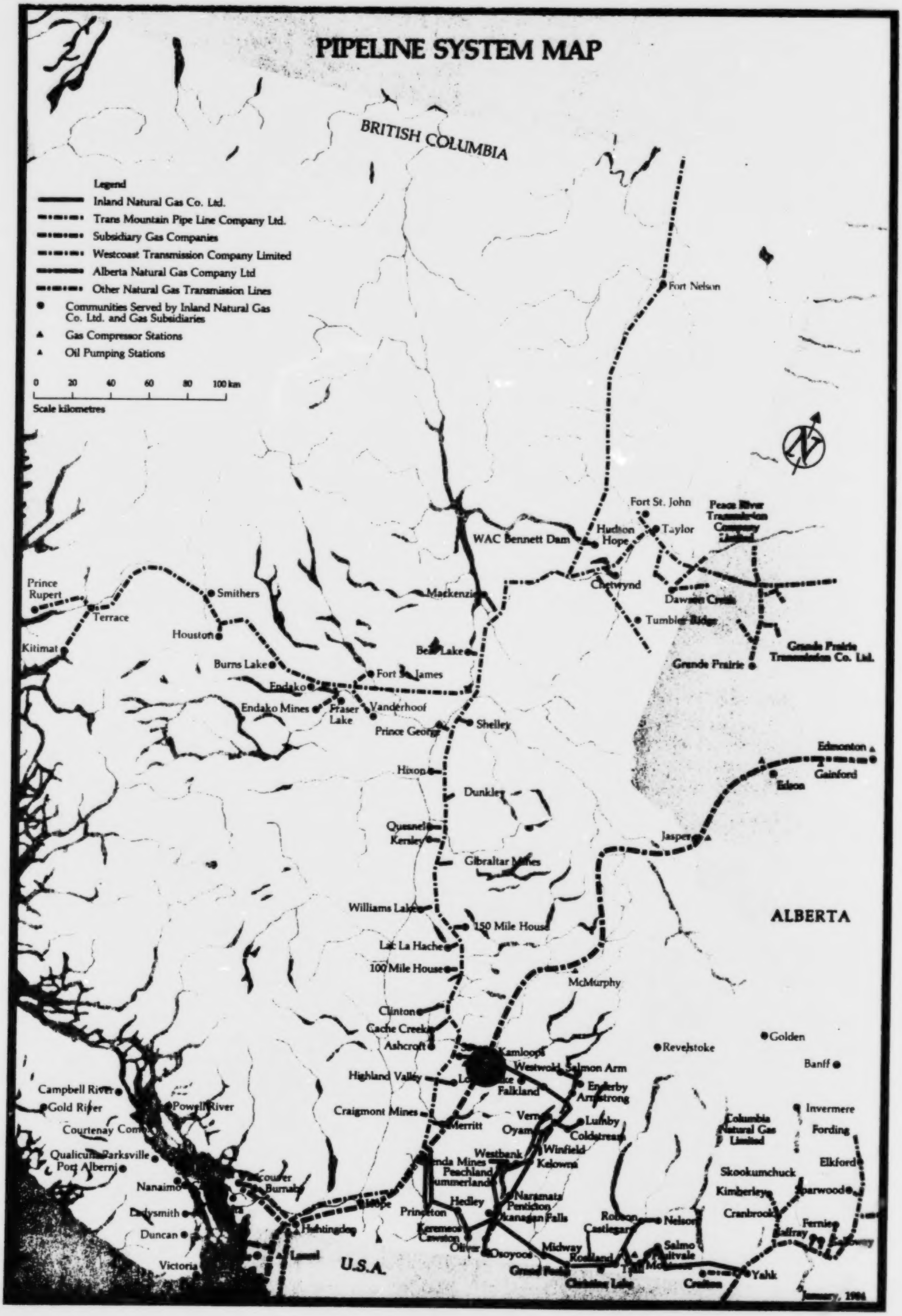
NOVEMBER, 1985



PIPELINE SYSTEM MAP

BRITISH COLUMBIA
Legend
Inland Natural Gas Co. Ltd.
Trans Mountain Pipe Line Company Ltd.
Subsidiary Gas Companies
Westcoast Transmission Company Limited
Alberta Natural Gas Company Ltd
Other Natural Gas Transmission Lines
Communities Served by Inland Natural Gas Co. Ltd. and Gas Subsidiaries
Gas Compressor Stations
Oil Pumping Stations
0 20 40 60 80 100 km
Scale kilometres
N
Fort Nelson
Fort St. John
Taylor
Peace River Transmission Company Limited
Hudson Hope
WAC Bennett Dam
Chetwynd
Dawson Creek
Tumbler Ridge
Grande Prairie
Grande Prairie Transmission Co. Ltd.
Prince Rupert
Terrace
Kitimat
Smithers
Houston
Burns Lake
Mackenzie
Bear Lake
Fort St. James
Endako
Endako Mines
Fraser Lake
Vanderhoof
Prince George
Shelley
Hixon
Dunkley
Quesnel
Kersley
Gibraltar Mines
Edmonton
Gainford
Edson
Jasper
Williams Lake
150 Mile House
Lac La Hache
100 Mile House
ALBERTA
McMurphy
Clinton
Cache Creek
Ashcroft
Kamloops
Revelstoke
Golden
Banff
Westwold
Salmon Arm
Highland Valley
Logan Lake
Falkland
Enderby
Armstrong
Campbell River
Gold River
Powell River
Craigmont Mines
Vernon
Oyama
Lumby
Coldstream
Merritt
Invermere
Columbia Natural Gas Limited
Fording
Courtenay Comox
Qualicum Parksville
Port Alberni
Winfield
Westbank
Kelowna
Brenda Mines
Peachland
Summerland
Elkford
Skookumchuck
Kimberley
Sparwood
Nanaimo
Vancouver
Burnaby
Hedley
Naramata
Penticton
Okanagan Falls
Cranbrook
Fernie
Galloway
Ladysmith
Hope
Princeton
Robson
Castlegar
Nelson
Baffray
Duncan
Huntingdon
Keremeos
Cawston
Oliver
Osoyoos
Midway
Rossland
Salmo
Fruitvale
Trail
Montrose
Victoria
Laurel
U.S.A.
Grand Forks
Christina Lake
Creston
Yahk
January, 1984

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Results of the Kamloops Marketing Project

Over the period January, 1983 to April, 1985, some 145 vehicles were converted to operate on natural gas. Since April, a further 45 vehicles have been converted, indicating that the program has started to gain some momentum of its own. Inland staff involved in the program report the following findings:

- the vehicles converted represent a wide variety of the high-usage vehicles in Kamloops, with particular emphasis on those that operate primarily within the city (many Kamloops vehicles use the city as a base for highway travel out to resource industry sites or smaller centres, and do the majority of their mileage on the highway)
- the majority of users are happy with their conversions, citing the saving in fuel costs as the chief benefit
- the main problems for users are noted as power loss, loss of carrying space, and more frequent refuelling
- the most notable technical failure was the conversion of six school buses by the local school board; these showed high power losses, inadequate range, and unacceptable reliability and the conversions were removed after a few weeks. Two conversions were transferred to school district vans
- the conversion kit was removed from one other vehicle by its owner, who said that power losses were too severe
- one two stroke diesel vehicle, a Highways Department truck converted in Vancouver, is operating on natural gas in the Kamloops area
- the cost of the marketing and promotion, in both money and manpower, was considerable at the beginning; present marketing efforts are limited to responding to enquiries.

In summary, the Kamloops marketing project indicated that substantial numbers of vehicles can be recruited for an initial station if an all-out marketing effort is undertaken, and all aspects of the initial introduction are covered.

As a result of their involvement in marketing, compressor installation, and vehicle conversions, Inland personnel have gained an excellent appreciation of the problems that can face fuelling station operators and vehicle owners, particularly in the first few months. The comments on the technical aspects are found throughout this report, and reflect their experience not only with the 50-vehicle test fleet, but also with the rest of the Kamloops conversions.

Continuation of the Marketing Program

It is Inland's intention to continue with the present arrangement with the Mohawk station for at least another two years. During that time, the vehicle fleet should continue to increase to the point where another fuelling installation will be justified in the Kamloops area. The most likely area for the second station is across the Thompson River, on the north side. North side vehicle owners feel that a station in their area would make it far more convenient for them to use NGV.

Inland continues to be active in NGV marketing in British Columbia. In addition to the company's assistance in establishing privately owned fuelling stations in Prince George and Vernon, and at the Lornex mine site, Inland has become a founding member of the NGV Association of B.C., and is actively playing its part in the development of the industry through participation in the Canadian Gas Association and the Pacific Coast Gas Association.

As noted earlier, Inland intends eventually to establish a network of fuelling stations throughout its franchise area, enabling NGV owners to travel on natural gas from one end to the other. Since the major towns in the B.C. interior are linked by a network of some 4000 miles of main highways, this is not a small undertaking. However, the company's long term vehicle targets, when achieved, would involve enough vehicles in the 19 major market centres to justify this fuelling network.

With its experience, the company is also placing considerable emphasis on the conversion of larger fleets in the B.C. interior. Such fleets would be able to utilize captive refuelling installations, and would not be dependent on the establishment of public stations.

Government Assistance

Inland has made full use of assistance programs from both the Federal and Provincial governments. The Energy, Mines, and Resources capital grant of $40,000 was applied to the original cost of the compressor, and the $10,000 operating subsidy is being applied to maintenance costs.

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EXECUTIVE SUMMARY

In early 1983, Inland Natural Gas Co. Ltd. opened the first natural gas fuelling station in the interior region of B.C., at Kamloops. At the same time, the first vehicle conversions in Kamloops were carried out. Owners of these vehicles included private couriers, independent businessmen, the RCMP. departments of the provincial and local government, and of course Inland itself. By mid 1983, over 50 Kamloops area vehicles were running on natural gas; now (late 1985) there are nearly 200.

Under a contract with Supply and Services Canada on behalf of Energy, Mines, and Resources (23SQ.23216 - 2 - 6765 - 1) Inland undertook to report on its experience with the fuelling station and a mixed vehicle fleet, over a two year period. This final report fulfils that commitment.

MARKETING

Inland is one of the first Canadian gas distribution companies to undertake the active marketing of natural gas for vehicles (NGV). The company has identified a substantial number of candidate vehicles in its franchise area, and it is clear that NGV offers promising potential for gas sales expansion.

In 1983, the Canadian NGV industry was small and poorly organized. Because its market area consisted entirely of small communities with no NGV infrastructure, Inland found it necessary to take responsibility for virtually all aspects of market development. This included the specification, purchase, installation, and servicing of the compressor and fuelling equipment, the purchase, warehousing, and wholesaling of vehicle conversion kits, and the initial leasing of conversion space. Fuelling service was provided through an arrangement between Inland and a twenty-four hour self-serve station owned by Mohawk Oil Co. Ltd.

Inland undertook the active promotion and marketing of natural gas as a vehicle fuel, and provided the technical support for both fuelling and vehicle conversions. The company leased and equipped a showroom at the Mohawk station. Without constant tangible evidence that Inland fully supported the introduction of NGV, the fuel would not have gained a foothold in Kamloops.

NGV's percentage of the automotive fuel market in Kamloops is still small, but new conversions continue to come on stream and gas sales are growing steadily. Inland is installing an additional dispenser and high pressure storage modifications at the fuelling station. Some vehicle operators have now been using NGV for almost three years, and have shown substantial savings. Inland has gained the confidence to expand its NGV marketing thrust throughout its franchise area to many of its major industrial customers.

FUELLING

The B.C. Utilities Commission granted Inland special permission to retail compressed natural gas directly to the public. This location was the first in B.C. to dispense natural gas on a self-serve basis to the public, though the staff of the Sahali Mohawk station provide service when required.

The compressor installation includes an Idromeccanica DP2-20-10 hydraulic compressor, skid mounted in a sound insulated aluminum shelter, together with 43 bottles for high pressure storage. Inlet gas is taken from an intermediate pressure main at about 200 psig; the machine delivers approximately 250 scfm at 3600 psig. This is sufficient capacity to service the fuel needs of 150 varied vehicles through one twin-hose dispenser. A second dispenser is now being added to eliminate queues. A gas dryer has also been installed to eliminate "freeze-offs" due to the occasional receipt of wet gas. A cascade sequencing control is also being added to improve utilization of the high pressure storage.

The compressor has had many problems, requiring a great deal of attention from Inland's maintenance staff, and causing considerable downtime. Some of these are a direct result of wide seasonal and daily temperature swings in the area. Current technical improvements, and a strict preventative maintenance schedule, are now reducing the frequency of failure. No serious safety problems have occurred.

Despite abnormally high compressor maintenance costs, the installation makes a modest profit serving about 150 vehicles. Based on this experience, the economics for industrial fleet installations also appear favourable.

THE VEHICLE FLEET

The vehicle fleet monitored under this contract is a representative cross-section of the wide variety of Kamloops vehicles equipped with natural gas conversions. Because of wide temperature and altitude variations, Kamloops tests conversion equipment severely, and the first generation kits used require skilled mechanics to keep the vehicles operating well.

The results of vehicle monitoring showed wide variation. Some vehicles, with high fuel consumption, travelling up to 4000 kilometers monthly on natural gas, showed annual financial returns on the conversion investment of over 100%. Others, with lower utilization, and a lower percentage of their time on NGV, did not do as well.

Inland's continuous marketing and technical support was very important to the vehicle operators throughout the test period. A positive attitude on the part of the vehicle operator is clearly vital to a successful conversion. If the operator directly benefitted from the dollar fuel savings, the results were usually excellent.

THE FUTURE

Inland plans to continue its support of retail fuelling in Kamloops, and of two privately-owned NGV outlets in Vernon and Prince George. The company has also identified 19 market areas in the interior of B.C. where fuelling outlets could be supported.

The company also plans a substantial marketing effort aimed at the conversion to natural gas of some major fleets owned by industrial and resource extraction customers. Inland's early experience in Kamloops has been invaluable in gaining a head start on this important market.

SECTION 1 - HISTORY AND BACKGROUND

Five years ago, there were less than a dozen natural gas vehicles in Canada. Natural gas had been used in Italy for many years as an automotive fuel, and New Zealand had started a massive government-sponsored effort to convert vehicles to natural gas operation. Canadians had virtually no experience with compressed natural gas handling, storage, or carburetion.

The introduction of natural gas for vehicles (NGV) into Canadian markets was, at first, extremely slow. Compressors and fuelling facilities represented large front-end expenditures for fuel retailers, vehicle owners faced substantial investments in conversion equipment, and there was considerable doubt as to the long-term viability of the fuel. In addition, a variety of technical problems were surfacing as foreign technology in fuelling stations and vehicle systems was adapted to Canada's severe operating conditions, and to the changing automobile technologies of the 1980's.

The use of natural gas as fuel for Canada's road transportation offers clear advantages to the nation; Canada has ample supplies and it can be produced and distributed economically. For the user, it offers substantial cost savings. Yet despite these advantages, vehicle owners and potential distributors alike remained skeptical, citing lack of operating experience as a reason for not committing themselves. And while vehicles were being converted, and fuelling stations being built in many parts of Canada, information on the results was not being collected or distributed to potential users and marketers.

Inland Natural Gas Initiative

Inland Natural Gas Co. Ltd. is a regulated gas distribution company operating throughout the interior region of British Columbia. Like many other gas distributors, Inland, in 1981, was examining the potential of natural gas as a vehicle fuel as a means of increasing its sales within its franchise area. An internal company report in the fall of 1981 proposed a pilot marketing effort based in Kamloops, a city of 65,000 in the southern interior of B.C.

Unlike many gas marketers who had targeted large fleet operations as the first customers for NGV, Inland had to face the fact that there were, in Kamloops, no fleets large enough to justify, by themselves, the cost of a fast fill compressor installation of reasonable capacity. The threshold number, from Inland's calculations, appeared to be approximately 140 vehicles. It would therefore be necessary to undertake considerable marketing effort to a number of vehicle owners in Kamloops, and to draw initial users from a wide variety of businesses and services.

INLAND'S PROPOSAL

At that time, Energy, Mines, and Resources requested proposals which would result in records being kept on a fleet of some 50 vehicles, in order to make available authoritative operating experience to potential users and natural gas marketers across Canada.

The proposal which was made by Inland resulted in the contract on which this document reports. The major features of this proposal were:

- Inland would monitor the operational experience with a fleet of 50 diverse commercial vehicles, over a period of two years
- Inland would also monitor experience with the compressor and fuelling equipment
- the fuelling station would be located in a publicly-accessible location
- Inland would carry out all marketing, education, and training necessary, and would ensure that both fuelling and vehicle installations met all applicable standards and regulations
- Inland would collect operator and maintenance staff reaction and marketing survey information, in order to assist in future marketing efforts.

Like other gas marketers, Inland also needed evidence about and operating experience with the fuelling and operation of converted vehicles. The company thus welcomed the opportunity to undertake, with funding from Energy, Mines, and Resources Canada, the collection, interpretation, and analysis of data on the operation of the fuelling station and the operation of some 50 selected vehicles.

The NGV Fleet Vehicle Demonstration

The resultant contract (23SQ.23216-2-6765-1) set out as its formal objective the capture of data on "a captive light duty commercial vehicle fleet". In particular, the contract specified:

- the collection of information on fuel distribution and dispensing methods, as well as some assessment of the relative costs and merits of public refuelling stations versus captive fleet applications
- demonstration of the use of NGV in vehicle operations and identification of the problems associated with its use
- investigation and assurance of safety in all aspects of the handling and use of NGV as a vehicle fuel, and the adherence to all applicable regulations
- the analysis of data on NGV operation as it affected fuel consumption, vehicle range, performance, and costs
- the identification and analysis of any non-hardware barriers to implementation, including certification, regulations, training, etc.

The contract was to commence on September 16, 1982, and run for 26 months. Due to considerable delay in obtaining the fuelling compressor, resulting in the start of vehicle fuelling, and hence data collection, being set back to January, 1983, the contract was extended to the end of September, 1985, with the final report due on December 2, 1985.

The actual key dates are:

- Permission received from B.C. Utilities Commission to proceed: September, 1982
- Start of natural gas sales for vehicles in Kamloops: February, 1983
- Start of vehicle data collection: September, 1983.

MARKETING APPROACH

At the time when Inland started NGV marketing in Kamloops, the field was still in its infancy. Following the First International Conference on NGV in Vancouver in the fall of 1981, the first fuelling stations had been established in Vancouver and Toronto, and the Black Top Cabs fleet had started operation in Vancouver. However, there was no doubt about the need, at that time, for more operating data.

No natural gas vehicles had ever operated in the interior region of B.C. With wide swings in daily temperatures, a winter-to-summer temperature range of over 80° Celsius, and an altitude range of from 500 to 900 metres above sea level, Kamloops had the potential to provide excellent operational testing. In addition, as a small town, it was possible to serve vehicles from many different fleets from one fuelling point without severe inconvenience.

Inland faced the problem of NGV marketing in a completely new area; the company's strategy was to install fuelling facilities at an easily accessible public station, and carry out active marketing throughout Kamloops (with an initial target of 140 vehicles, including the company's own fleet). The collection of detailed data on a selected 50 vehicles for EMR fitted well into that strategy.

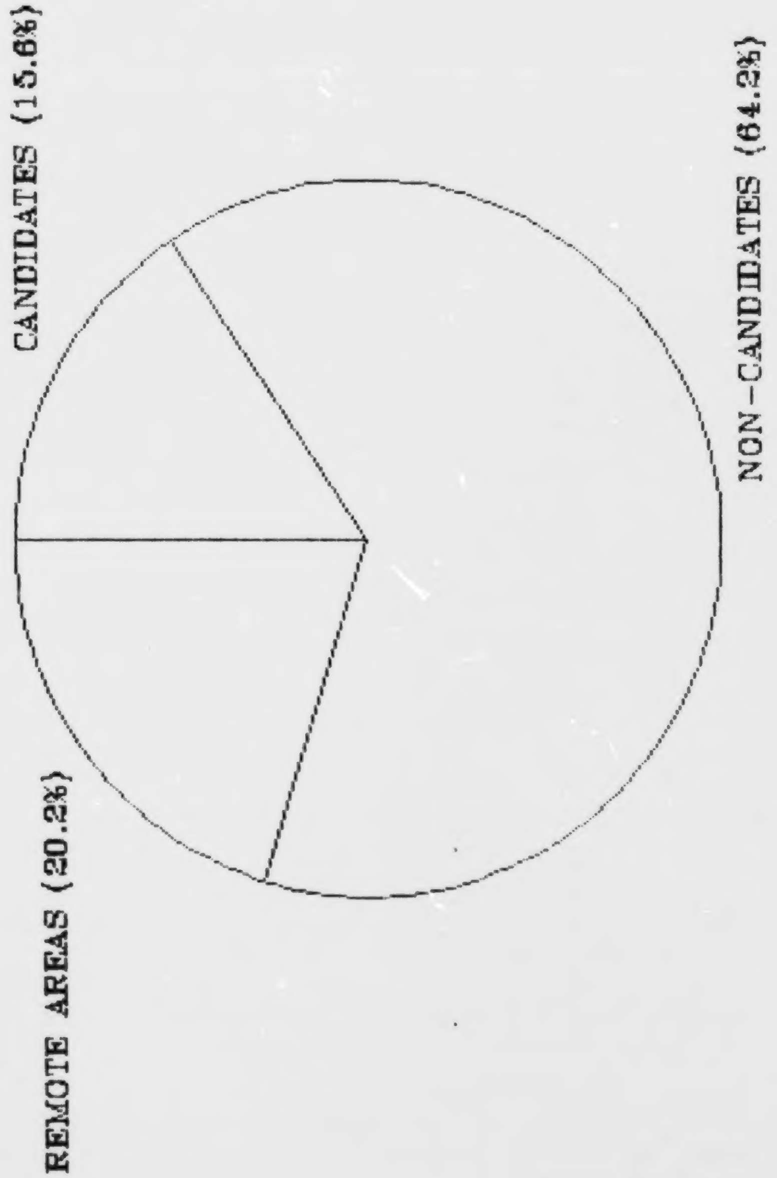
Market Potential in the Inland Market Area

Inland's franchise area, the interior of the province of B.C., has a population of some 400,000 scattered in relatively small centres over an area of some 500,000 square miles. The company provides gas to residential, commercial and industrial customers through its own network of distribution pipelines, and also through a series of spur lines connected to the Westcoast Transmission and Alberta and Southern long-distance gas transportation systems.

The economy of the area is based on mining, forestry, pulp and paper, and related basic industries. Growth for the next few years is anticipated to be slow, and Inland faces the problem of enlarging its markets for natural gas within a somewhat static economy. Its industrial market penetration has been quite successful, and residential heating is now largely gas.

Consequently, the prospect of opening an additional market in natural gas for vehicles is extremely attractive for Inland. The company has now identified, through studies of the vehicle population in its franchise area, a total of 11,400 commercial and 35,600 private "prime conversion

EXHIBIT 1 - PRIME CONVERSION CANDIDATE VEHICLES



candidate" vehicles in 19 key markets (centres large enough to economically support a fuelling facility). This is illustrated in Exhibit 1.

Current experience seems to suggest that the energy use per converted vehicle is in the range of 150 gigajoules per year, which is in excess of the average residential customer in the service area. As a result, the company has set targets for vehicle conversions in the next five years which would result in additional gas sales amounting to some 13% of today's residential load.

The company recognises that this level of market penetration is eventually dependent on the establishment of a chain of fuelling stations covering the highway network, which is the backbone of transportation in the B.C. interior. However, Kamloops was the logical place to start, as one of the largest centres and also the base for a substantial fleet of the company's own vehicles. At this point (November, 1985) stations have also been opened in Prince George and Vernon, in addition to the station in Kamloops which is the subject of this report.

Specific Plans and Marketing Activities

Despite provincial government backing and a favourable regulatory climate towards the introduction of natural gas for vehicles in B.C., Inland was very much "starting from scratch" in Kamloops at the end of 1982. The company had made the decision that it would take the initiative in all facets of promotion, marketing, and infrastructure, in order to ensure co-ordination between the "chicken and egg" elements of vehicle conversion, fuelling installation, and marketing.

Specifically, the following activities were undertaken by Inland:

- introduction, promotion, and marketing of the fuel to vehicle owners and operators, both public and private, in the Kamloops area
- specification, engineering, ordering, and installation of the compressor and dispenser
- making an agreement with Mohawk Oil Co.Ltd., owners and operators of the gasoline station where the compressor and dispenser were to be installed, for on-site construction and subsequent operation of the fuelling station
- servicing of the compressor, using the company's own

service staff

- establishment of a showroom and NGV display at the station, conveniently across the street from the Inland office
- lease of a portion of the station for use as a conversion shop
- purchase and stocking of vehicle kits, equipment, and spares
- recruitment of three conversion shops to carry out the conversions
- conversion of the majority of Inland's own vehicle fleet
- training and familiarization of company employees, drivers, mechanics, and others with the technology of the vehicles
- training of firemen and other safety personnel

In addition, systems were set up, and equipment purchased, to carry out the monitoring required for the 50 vehicles in the test fleet; more details on this will be found later in this report.

This marketing effort was heavily concentrated at the end of 1982 and at the beginning of 1983, in order to recruit sufficient vehicles to make economic use of the compressor intallation, which came on stream initially in the middle of January, 1983. However, the marketing effort has been continuing throughout the trial period.

Sale of Compressed Natural Gas

While the NGV is dispensed at the Mohawk station by the station operator, the dispenser and compressor are presently owned by Inland and the compressed gas is sold by Inland. In the absence of a guaranteed demand at the start, no independent operator would be willing to undertake the capital cost of fuelling equipment installation. Inland had the technical expertise necessary to maintain this equipment and the company took the initiative.

Inland expects that, when the Kamloops market expands to the point that an additional fuelling station will be justified, it may be appropriate to hand over responsibility for retailing NGV at this installation to the station operator.

Vehicle conversions have made use of grants from Energy, Mines, and Resources ($500 per vehicle). Many of the station customers have also been eligible for the B.C. Government grant ($200 per vehicle) applicable to privately-owned vehicles.

Through its marketing experience, Inland recognises the extreme importance of these grants in improving the economics of fuelling stations and conversions to the point where station operators and vehicle owners will make the key initial commitment. Inland also recognises the persuasive power of a time payment scheme (as presently offered by B.C. Hydro) in obtaining that commitment, and has made application to the B.C. Utilities Commission to allow Inland to institute and finance such a scheme in its franchise area.

Recruitment of the Demonstration Fleet

Drivers in the demonstration fleet were required to maintain complete records of the fuel used and hours driven on NGV and gasoline for their vehicle, and also to make their vehicles available for performance and emission testing. It was therefore essential to recruit drivers who would show sufficient interest in the project to carry on with this for two years or more.

Nineteen of the 50-vehicle fleet were drawn from Inland, and the rest came from a variety of fleets representing Government (Ministry of Highways, Ministry of Forests, City of Kamloops), utilities (B.C. Hydro), artisans (A&A Boiler Service, Kamloops Mechanical Contractors, Rayleigh Renovating, etc.), delivery (Kamloops Bottling, B.C. Bearing), messenger services (Prestige Parcel, Kamloops Industrial Express), and the local RCMP. The vehicle types were selected to provide a cross section ranging from one compact car through a wide variety of automobiles, pickups, and vans, to a few heavy trucks.

Utilization of the vehicles ranged from light (some of the Government cars) to very heavy (messenger service vehicles), with an interesting mix of city and highway driving. Because of the hilly terrain around Kamloops, the performance of vehicles was given a good test. Because of the duration of the trial, a full range of seasonal climatic variations and varieties of weather were encountered.

SUMMARY

At the time when this project was started, there was little Canadian experience with the NGV fuelling and operation. Inland took the initiative in its market area at a critical time. The next two sections of this report describe Inland's experience with the fuelling installation and with the vehicle fleet, over a two to three year period.

SECTION 2 - BUILDING AND OPERATING THE STATION

This Section describes the construction of the station, the installation of the compressor and other equipment, and Inland's experience with its operation.

B.C. UTILITIES COMMISSION PERMISSION

As in all provinces where privately-owned public utilities are regulated by a Board or Commission, the governing legislation in B.C. does not contemplate the sale by the utility of either motor fuel or compressed natural gas. It was Inland's intention to be the ultimate vendor to the public of the compressed gas (rather than the usual pattern, in which the regulated utility sells uncompressed gas to the fuelling station operator, who then compresses it and sells it to the vehicle owner). Inland also wished the capital cost of the compressor and other equipment to become part of the utility's "rate base", and the expenses incurred to be recognised as allowable in the normal course of business.

Inland therefore found it necessary to make application to the B.C. Utilities Commission to undertake the Kamloops NGV program. This application was originally made on August 9, 1982, and the Commission granted permission to Inland to carry out the program for a period of two years, subject to the condition that Inland:

> "submit to the Commission on a semi-annual basis reports on the operation of the Demonstration Project. A final report will be submitted following completion of the 24-month trial period, such report to provide appropriate details of revenues and costs, together with an assessment of market penetration, operating characteristics and future viability."

Inland was exempted by the Commission from the provisions of the Utilities Commission Act related to the requirement to file a retail tariff for gas dispensed at the facility. This allowed Inland the flexibility to establish retail pricing without requesting prior approval from the Commission.

Subsequently, Inland made application to the Commission to continue selling NGV at the Kamloops Mohawk station for a further two years. Inland has also applied for permission to initiate a conversion finance scheme for vehicle owners to assist with the high front-end costs of equipping vehicles for natural gas fuelling. The Commission is presently considering this request.

CONTRACTUAL ARRANGEMENTS WITH MOHAWK

The station at which Inland wished to install the equipment for compressed natural gas fuelling is located on the main highway, directly across from Inland's Kamloops office. It was therefore necessary to arrive at an arrangement whereby the fuel could be sold from the station's main pump island, through Inland's dispenser, using Mohawk's staff. Title to the gas would not be transferred to Mohawk at any time. Further, provision had to be made for the installation of Inland's compressor and dispenser on Mohawk's property.

The arrangement finally agreed upon contained the following elements:

- Inland would pay Mohawk a "dispensing fee", per unit of gas sold, for the services of Mohawk's staff, credit handling arrangements, and rent for the property occupied

- Mohawk would pay for the electricity used by the compressor, and deduct it from the gross amount collected from natural gas sales

- Inland would be completely responsible for the servicing of the compressor and dispenser

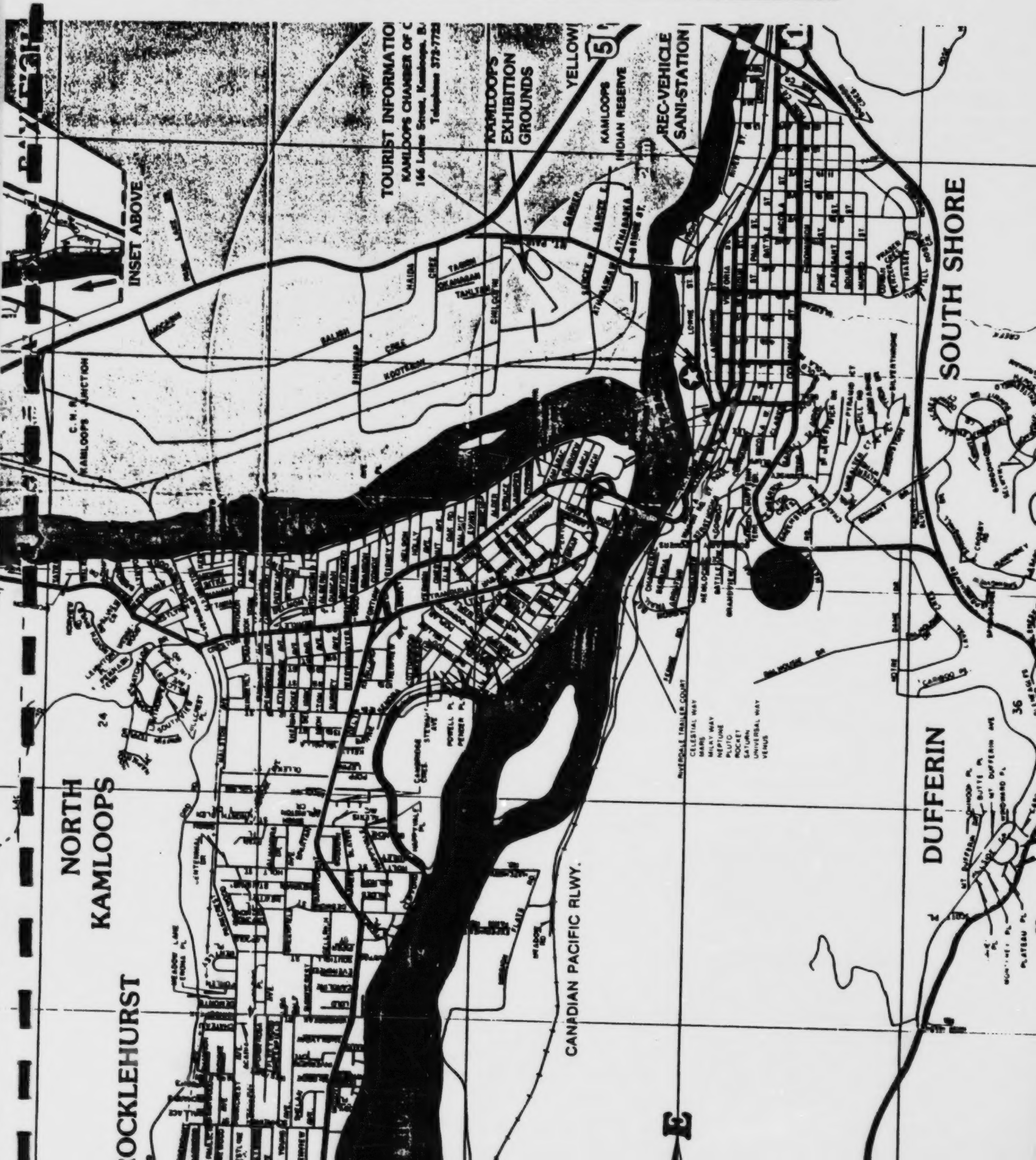
- Mohawk would be responsible for the electrical supply to the site, electrical interface to the dispenser, compressor foundation, paving and landscaping improvements.

This basis has continued to the present day without significant modification. A request for another two year extension to the term of the demonstration was authorized by the B.C. Utilities Commission on April 19, 1985, allowing the project to continue until it is reviewed again on February 28, 1987.

BUILDING THE STATION

The station is located at the intersection of Highway 93 (West Columbia Street) and McGill Road in Kamloops, easily accessible from downtown via Columbia Street, which is the main highway access from the south to downtown Kamloops. Accessibility to the western Kamloops industrial area and North Kamloops, is via McGill Road, which intersects, within a block of the station, with a new bypass road. This is a key corner location, as illustrated on the map (Exhibit 2).

EXHIBIT 2 - MAP OF KAMLOOPS SHOWING STATION LOCATION


NORTH KAMLOOPS
CANADIAN PACIFIC RLWY.
DUFFERIN
SOUTH SHORE
INSET ABOVE
C.N.R. KAMLOOPS JUNCTION
KAMLOOPS EXHIBITION GROUNDS
KAMLOOPS INDIAN RESERVE
REC-VEHICLE SANI-STATION
RIVERDALE TRAILER COURT
CELESTIAL WAY
MARS
MILKY WAY
NEPTUNE
PLUTO
ROCKET
SATURN
UNIVERSAL WAY
VENUS
5
1
24
36

The station is a self-serve outlet (like many others in Mohawk's chain) selling multiple fuels: leaded, unleaded, and unleaded premium gasoline, diesel, and propane (not self-service). The station also includes a 24-hour convenience store; the cashier is responsible for collecting fuel receipts. The building contains two large service bay areas, both of which were rented to Inland for use as a vehicle conversion shop on a sublet basis. Exhibit 3 is a photograph of the station.

In the fall of 1982, Inland's engineering group drew up specifications for a compressor and fuelling installation to be installed at the station. These specifications included the compressor, high pressure storage, a dispenser with calculating head, and the necessary piping and electrical switchgear. These are all described briefly in the following paragraphs, together with the equipment that was eventually purchased and installed. A plan of the station and the main components of the natural gas fuelling system is included as Exhibit 4.

The Compressor

In order to minimize energy costs for compression, Inland wished to take advantage of the fact that an intermediate pressure gas main, with a nominal pressure of 200 psig, was located down the street from the site. Thus the specification required an input pressure of 200 psig, an output pressure of 3600 psig, and the ability to deliver 250 scfm or more for direct fast fuelling of vehicles.

Inland purchased an Idromeccanica Model DP 2-20-10 hydraulically operated two stage compressor from CNG Fuel Systems Limited of Calgary, skid mounted and packaged in a sound insulated, ventilated aluminum shelter. (See Exhibit 5)

The discharge pressure of this compressor varies with inlet pressure but for 200 psig in, the machine delivers approximately 250 scfm at 3600 psig (Inland has not verified the manufacturer's claim regarding throughput but we believe it to be correct). The compressor is powered by a 100 hp, 600 volt electric motor.

High Pressure Storage

Inland adopted the approach that a minimum volume of high pressure storage would be required. Vehicles would be fuelled from high pressure storage until equilibrium was reached, and then "top-up" high pressure gas would be provided directly from the compressor, until the maximum

EXHIBIT 3 - SAHALI MOHAWK STATION

MOHAWK
SELF-SERVE

EXHIBIT 4 - PLAN OF THE STATION, FEBRUARY, 1983

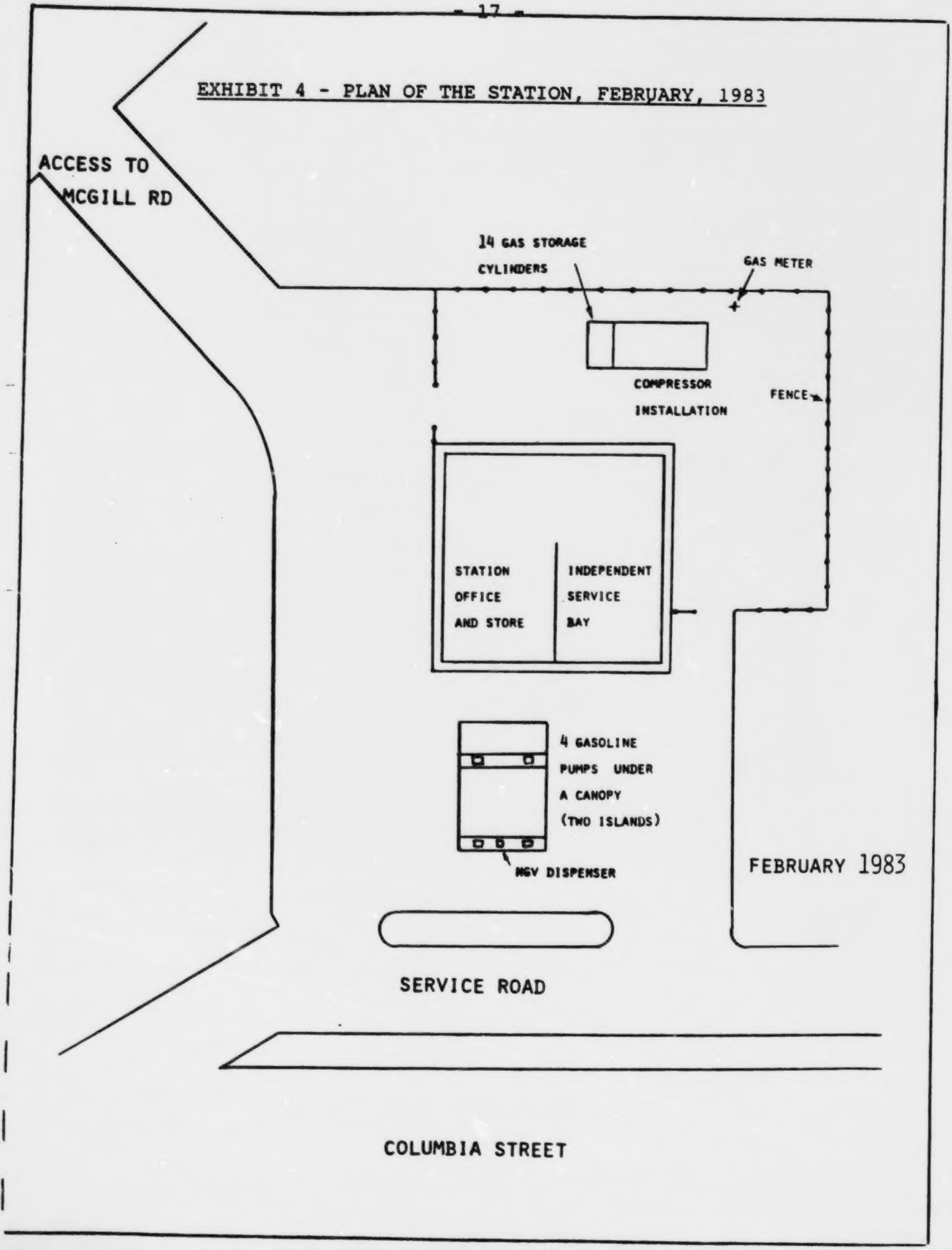
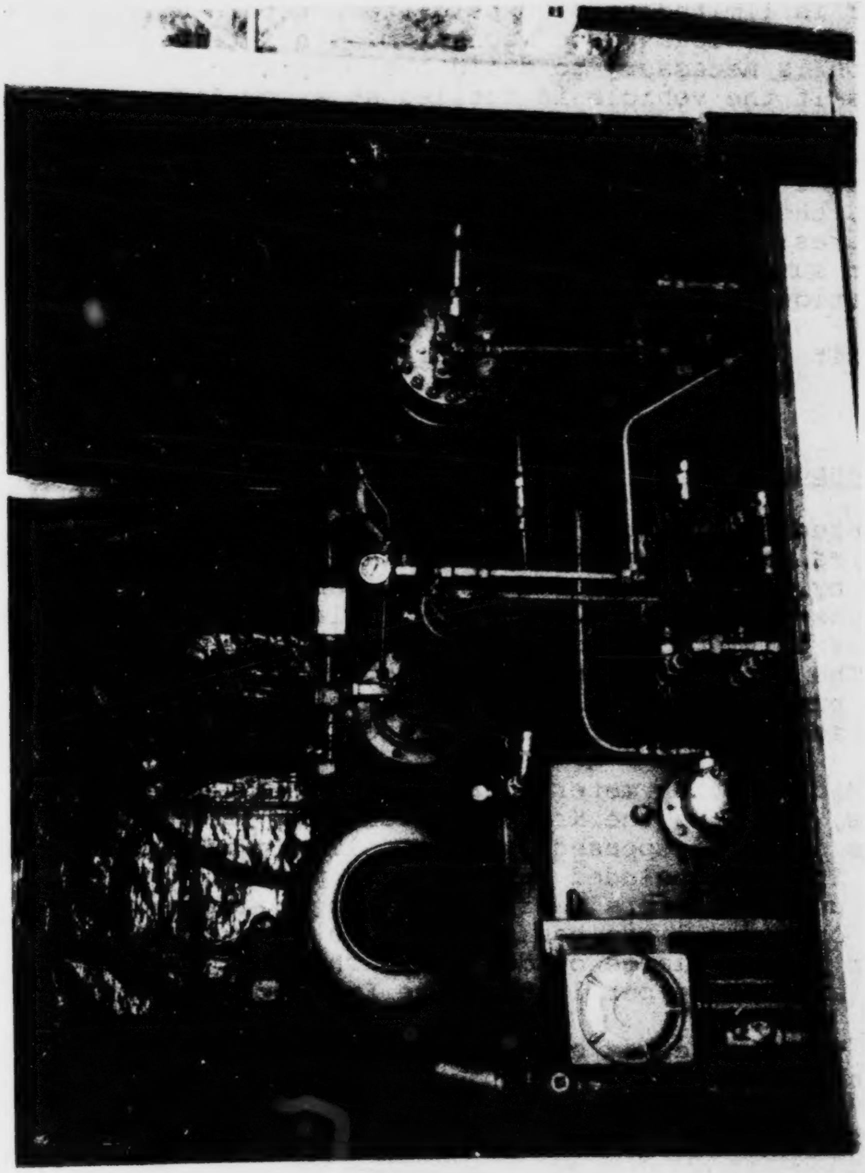

ACCESS TO
MCGILL RD
14 GAS STORAGE
CYLINDERS
GAS METER
COMPRESSOR
INSTALLATION
FENCE
STATION
OFFICE
AND STORE
INDEPENDENT
SERVICE
BAY
4 GASOLINE
PUMPS UNDER
A CANOPY
(TWO ISLANDS)
NGV DISPENSER
FEBRUARY 1983
SERVICE ROAD
COLUMBIA STREET

EXHIBIT 5 - IDROMECCANICA DP2-20-10 COMPRESSOR



pressure (depending on the temperature) was reached. Initially, 18 bottles were installed.

While the fixed storage pressure is 3600 psig nominally, the outlet pressure to the transfer piping and hence to the dispenser is limited to 3000 psig (temperature corrected to 70°F) by a dome load valve mechanism. This temperature correction is necessary to avoid overpressuring vehicle cylinders if the vehicle is fuelled at a low temperature and subsequently experiences high temperatures.

The dome load valve mechanism uses, as its reference pressure, the pressure in a vessel exposed to ambient temperatures; in Kamloops, temperatures cover a range from winter to summer of over 80°C. (For further discussion of the operation of this mechanism, see later in this report.)

Exhibit 6 shows the compressor enclosure with storage bottles.

The Dispenser

A dispenser with two fill hoses, gas measurement, and total price calculation equipment, was specified. This was supplied by CNG Fuel Systems Limited, and consisted of a Krause "gasoline-type" electronic display with measurement of the gas being provided by two Micro-Motion mass flow meters. The entire mechanism is mounted on a standard gasoline pump frame. The dispenser purchased was one of the first in service anywhere of its type.

The Micro-Motion meters measure the gas dispensed in Kilograms, and thus the Krause calculating head displays the Kilograms of gas dispensed and the dollar total accumulated. However, it was concluded early in the program that the motoring public prefers a direct pricing comparison to gasoline on a per litre basis. Thus the sign above the dispenser and the large outdoor sign show equivalency to gasoline at a price per litre. (See Exhibit 11.)

Once the compressed gas has passed through the flow meters it is dispensed through one of two high pressure flexible hoses and then through a standard CGA half-inch fill probe which is inserted into a receptacle on each vehicle.

Piping and metering

Natural gas is provided to the inlet of the compressor by a two inch nominal intermediate pressure main operating at 200 psig. This was connected to a main approximately two

EXHIBIT 6 - COMPRESSOR ENCLOSURE

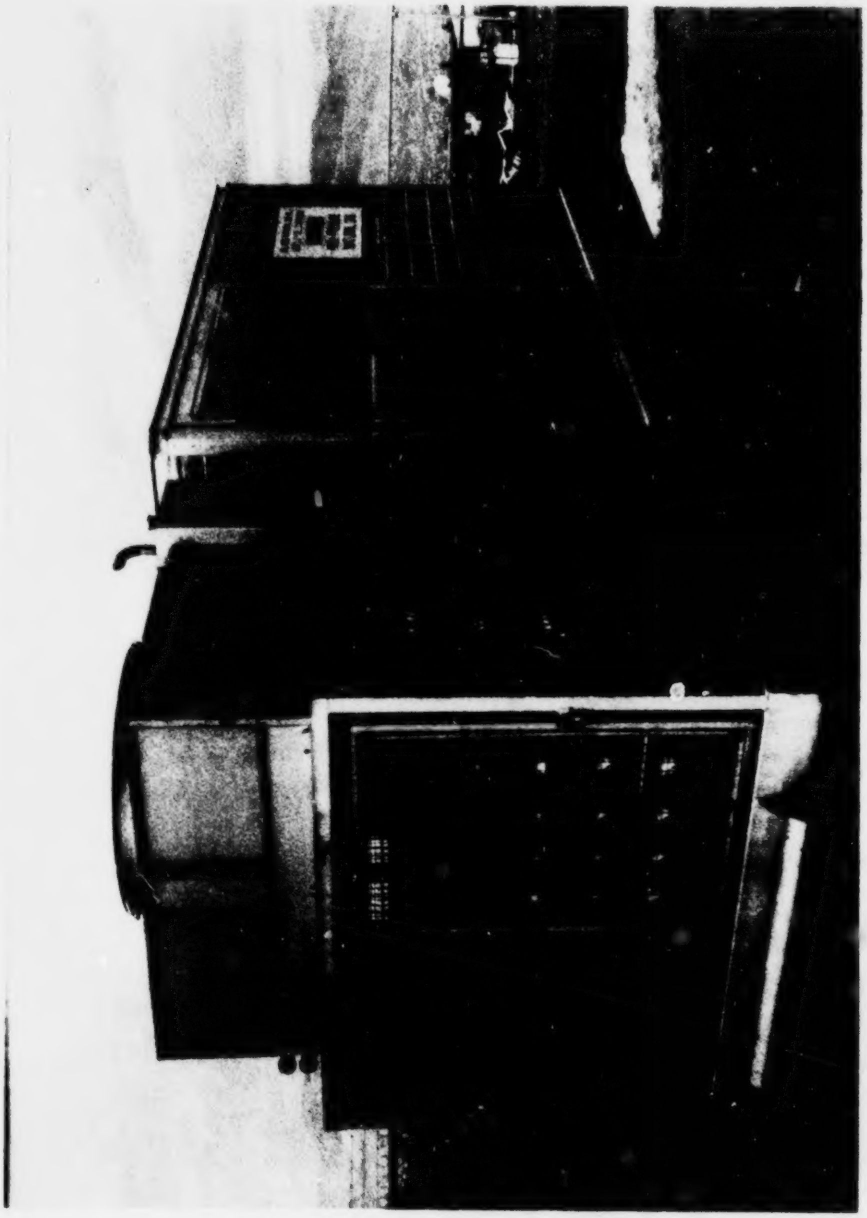
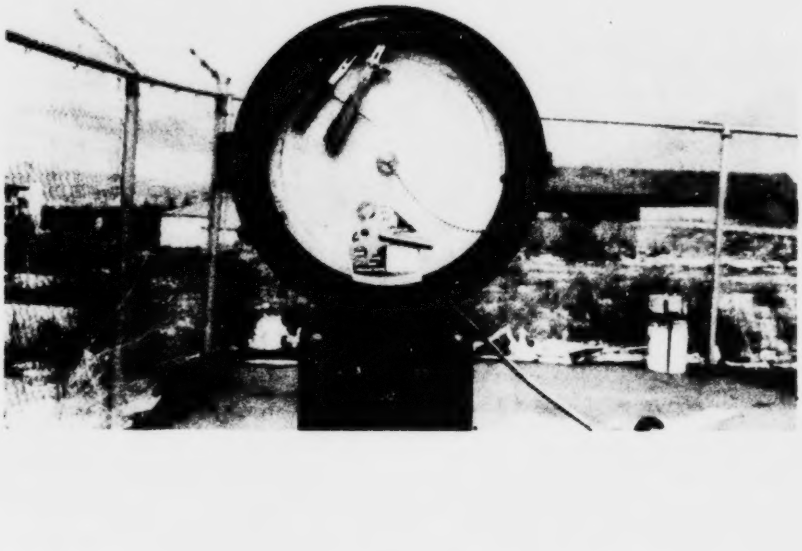


EXHIBIT 7 - INLET METER



blocks away along West Columbia Street, necessitating a permit from the B.C. Ministry of Highways and Transportation since the connection, in view of its size and pressure, fell under its jurisdiction.

Metering of the inlet gas to the compressor is provided by a positive displacement bellows-type standard meter set rated for the inlet pressure. (See Exhibit 7.) The meter is not being used for custody transfer since Inland retains title to the natural gas until it is transferred to the vehicle (accounting for custody transfer is therefore accomplished by the mass flow meters in the dispenser). The positive displacement meter does, however, provide a means of identifying and accounting for "lost gas", i.e. gas vented at times the compressor, fixed high pressure storage, high pressure transfer line or dispenser are being serviced. Under normal operating conditions the hydraulic compressor does not vent natural gas to atmosphere nor does it unload high pressure gas back into the suction line.

The high pressure discharge line leads underground from the outlet of the dome load valve to the dispenser. In view of soil conditions on the site, all underground pipes have been connected to Inland's main active cathodic protection system. The line was also equipped with an Emergency Shut Down valve actuated by crash stop buttons near the cashier's position and on the exterior front face of the building.

Electrical Installation

The 100 hp 600 volt electric motor driving the compressor is controlled by electrical switchgear located on the inside rear wall of the station, a concrete block building approximately 6 metres away. Included was an upgraded electrical feed to the station to handle both the station load and the compressor load. An Allen Bradley 2100 Vertical Motor Control Centre for across the line starting on 600 volts AC was also included.

The switchgear is contained in a specially constructed closet, in order to protect it from dirt, moisture, and damage.

Permits and Approvals

There were three major approval processes:

- as mentioned earlier, the B.C. Ministry of Highways and Transportation required a permit to allow the transmission of gas at 200 psig along a main roadway

- a building permit for the work was required from the City of Kamloops
- the British Columbia Department of Labour, Safety Engineering Services Division, approved the plans, the construction, and the final installation of all high pressure gas equipment. Staff of the Division have continued to work closely with Inland to ensure the safety of the installation.

Construction

Construction took place during the winter of 1982 - 83.

No particular problems were encountered. The intended location of the compressor skid showed evidence of being comprised of loose fill so it was necessary to place and drive six timber piles topped with concrete caps extending the width of the compressor skid. The unit was lifted from the transport trailer onto the pile caps by a single crane.

Compressor start-up took place on December 20, 1982, and the installation was commissioned in mid-January, 1983.

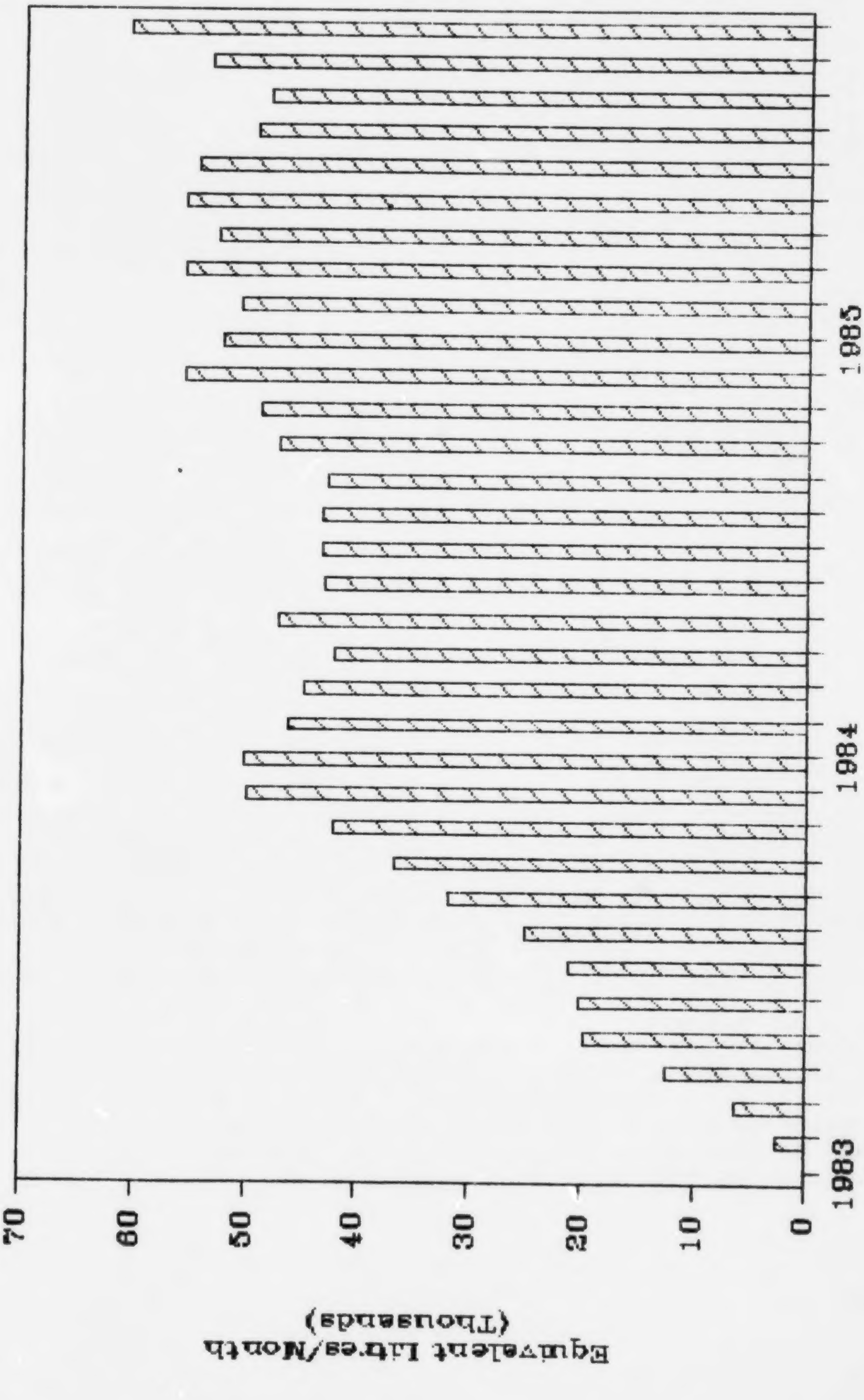
OPERATING EXPERIENCE

The fuelling installation has now been in operation for nearly three years. During that time, many operating problems have been encountered and overcome. These are described on the following pages, together with the implemented solutions. These are listed under the general headings of:

- Compressor maintenance
- Maximum pressure adjustments and fill capacity
- Dispenser maintenance
- Gas drying
- Self serve operation
- Safety

Sales of natural gas for vehicles from the fuelling station are shown in Exhibit 8.

EXHIBIT 8 - SALES OF NATURAL GAS FOR VEHICLES BY MONTH



Compressor Maintenance

Since the original startup of the compressor, gas has been available at the station for a total of some 25,200 hours, during which time the compressor has logged some 3,700 hours and recorded an estimated 295 hours of down time. During the first two years of operation, most of this downtime resulted from equipment failure, and thus impacted the availability of gas to customers, although it is estimated that some 30% of the downtime was covered by the availability of compressed gas from the high pressure storage. A graph of accumulated compressor operating hours is shown as Exhibit 9.

The major sources of compressor problems, as shown by the compressor log, have been:

- frequent failure of the hydraulic pump which provides the pressure to drive the pumping action of the cylinders
- insufficient heating of hydraulic oil in extremely cold weather
- insufficient cooling of hydraulic oil in extremely hot weather
- worn cylinder seals, and one experience of a scored cylinder
- worn solenoid valves and other electrical equipment on the compressor

Of these problems, the most severe was persistent failure of the hydraulic pump, (pictured in Exhibit 10) often at less than 200 hours operating time. A number of engineering changes have been made by the manufacturer, and operational procedure changes have been made by Inland in co-operation with CNG Fuel Systems since the first year; a spare is now kept on hand. Recent pump rebuilds have shown a life of close to 500 hours.

Over the past year, a preventive maintenance program has been initiated, which has not only reduced downtime by one-third, but has also enabled maintenance to be scheduled conveniently during periods of low customer demand. The impact of compressor servicing on availability of gas to customers has therefore been much reduced.

EXHIBIT 9 - CUMULATIVE COMPRESSOR HOURS

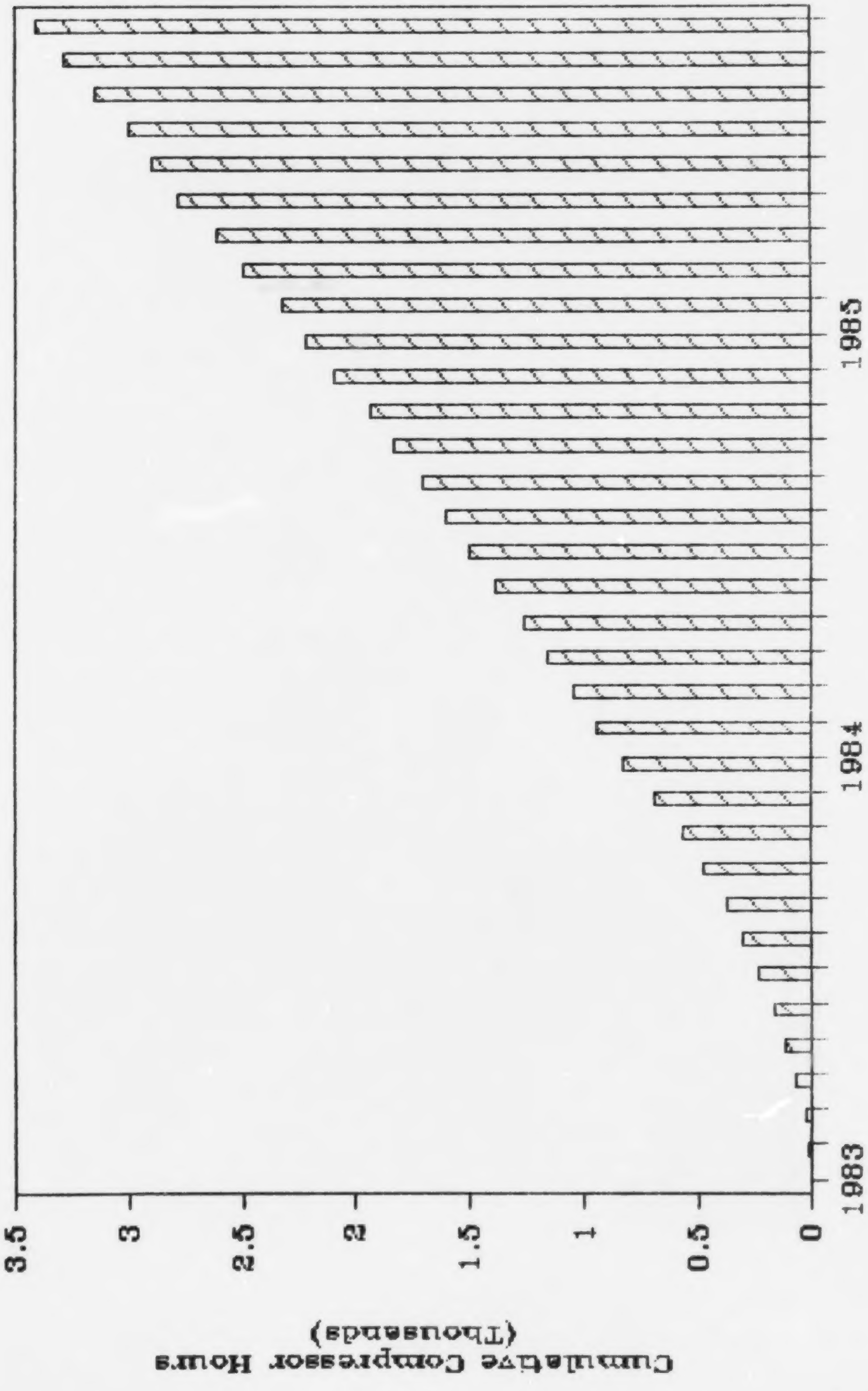
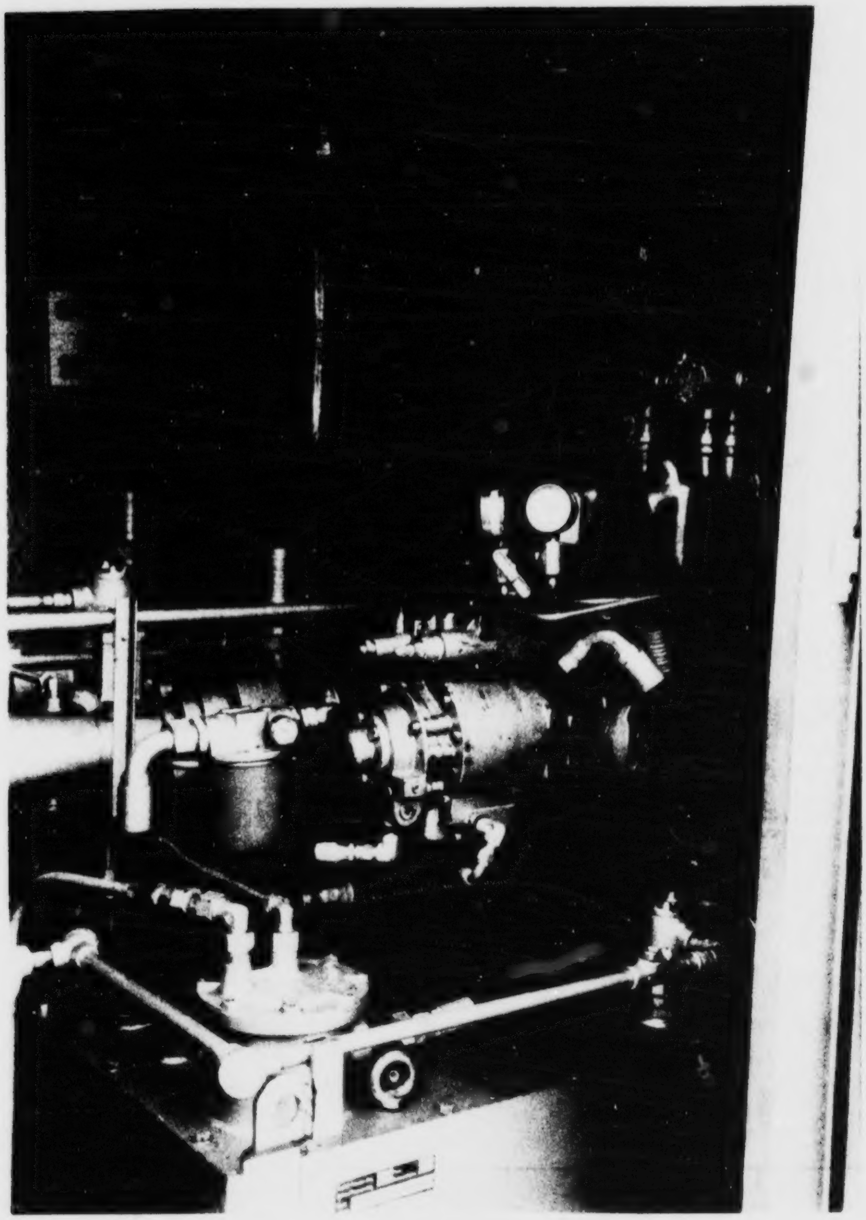


EXHIBIT 10 - COMPRESSOR HYDRAULIC PUMP



Gas Losses

As noted earlier, the Idromeccanica design of compressor does not permit the loss of gas to the atmosphere or its recirculation to the intake supply. Neverthless, readings were taken in early 1984 to check the readings on the intake meter (see Exhibit 7) with the gas sold as measured by the Micro Motion mass flow meters.

Since the intake meter measures gas by volume, and the Micro Motion meters measure the mass of the gas, a number of corrections had to be assumed for average gas density, pressure, and temperature. The result of this calculation was that the intake meter apparently read 3.54% lower than the gas sold as measured by the Micro Motion equipment. However, it should be noted that density, temperature, and pressures used as a basis for the calculation were estimated averages over a period of a month, and could well account for this difference.

Power Consumption

During the first six months of operation, a very high power factor was traced to the power supply to the electric motor on the compressor. This indicated that the current demand for starting the motor from rest was very much higher than that required to run it (normally, power demand ranges from 40 to 92 amps over the compressor stroke); this would have resulted, had it continued, in an 80% increase in electricity costs.

This problem was rectified through the installation of a load adjuster in the power supply to the electric motor. Power costs, monitored over a three month period after the load adjuster was installed, averaged $.0211 per kilogram.

The only known shutdown for electrical reasons occurred when a mouse was found to have shorted one of the circuits. The mouse, unfortunately, is no longer available for interview.

High Pressure Storage

Initially, the installation had been fitted with only 18 bottles of high pressure storage in the expectation that vehicles would receive their initial fill from the high pressure storage but would be "topped up" by the compressor. It was soon apparent that the volume of high pressure storage was insufficient; vehicle fuelling times started to lengthen as soon as more than one vehicle arrived for fuelling in quick succession, and there were very frequent compressor startups, resulting in an increase in wear.

A further 25 bottles were added to the high pressure storage bank, resulting in the current total of 43. (See Exhibit 6.) This appeared to reduce the startup problem, and even provided sufficient capacity to fuel vehicles when the compressor was down.

The existing system of single bank storage was maintained. It is now planned, however, to install a cascade system to switch the flow of gas between banks of bottles operating at different pressures, and further speed the filling of successive vehicles. This means that the basic approach to vehicle fuelling will have changed from:

- filling the vehicle from high pressure storage, and starting the compressor to "top up" the vehicle when necessary; then continuing compressor operation to recharge the high pressure storage, to
- filling the cascade from the compressor, and then using the cascade to fill the vehicles, then starting the compressor to recharge the cascade when necessary, starting with the high pressure bank.

The objective of these changes is to reduce the number of compressor starts, and to run the compressor longer when it is started.

Filling Pressure

As noted earlier in this report, the original system of controlling the fill pressure utilized a dome load valve to determine the maximum pressure to which a vehicle could be filled, dependent on the ambient temperature. The purpose of the dome load system was to ensure that whatever the temperature, the maximum pressure rating would not be exceeded at 70°F. The dome load valve was set, in practice, to 3000 psi at 70°F.

During the winter months, drivers became concerned that they were not getting a proper fill of natural gas when their vehicles were fuelled. To alleviate this problem, the dome load reference pressure was raised during the winter, and lowered during the summer. This was, however, obviously only a temporary expedient.

On analysis, it appeared the problem arose because the gas actually reached the vehicle at temperatures which were considerably greater than the ambient temperatures, particularly during severe winter weather. The heat generated by the compression of the gas was often not dissipated in the high pressure storage and piping system. The solution lies in adjusting the pressure of gas delivery according to the temperature of the gas, not the ambient temperature. A new reference chamber for the dome load system has been ordered; it will sense the actual gas temperature when it leaves the storage bank. (It is possible, of course, that the new cascade system will also result in more moderate gas temperatures.)

Dispenser Maintenance

Maintenance records indicate that less than 17 hours of downtime can be attributed to equipment failures in the dispenser over a 35 month period; this speaks well for the basic reliability of the mechanism. The dispenser was one of the very first of its kind, however, and a number of running modifications were made, particularly in the first year of operation. A photograph of the dispenser is shown as exhibit 11.

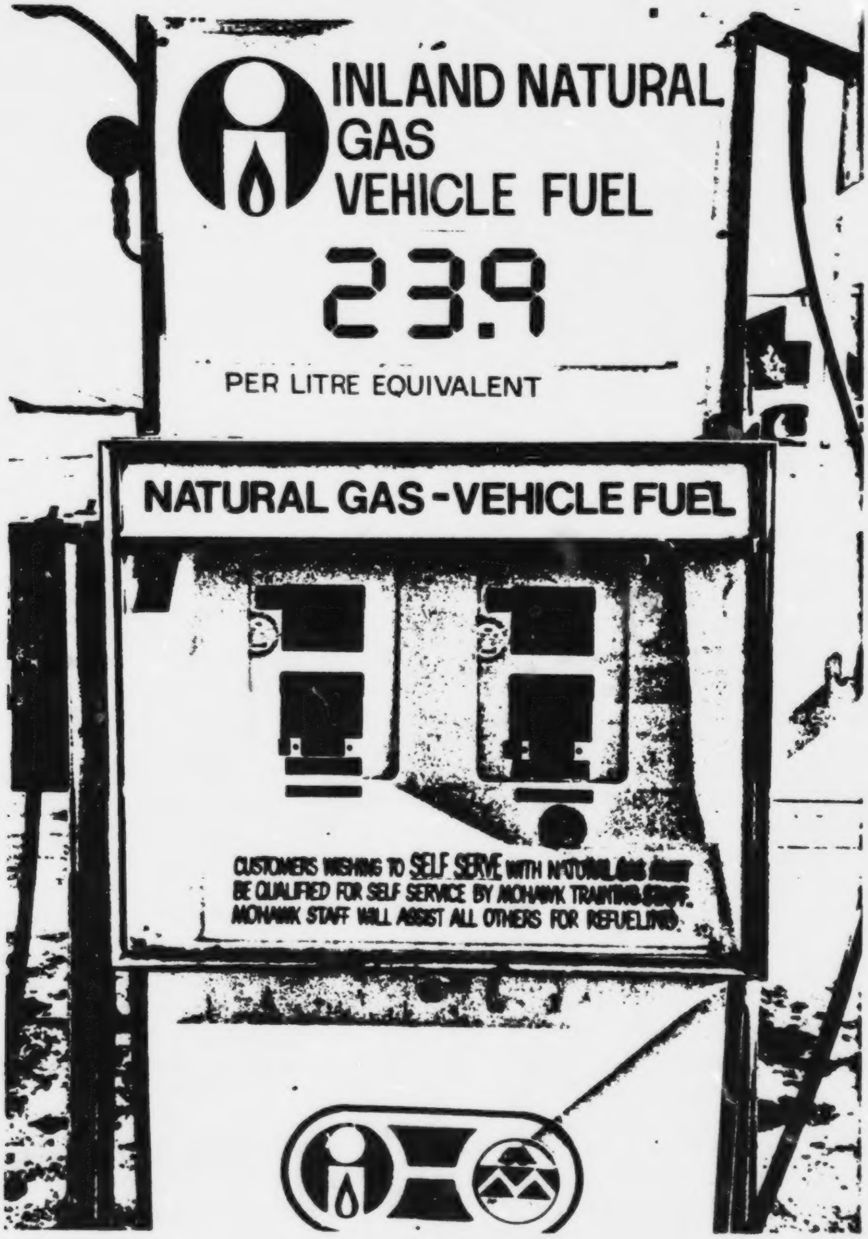
The Micro-Motion mass flow meters are sensitive to heavy vibration. This problem appeared even though each meter is mounted on a heavy steel plate, and the dispenser is bolted firmly to the pump island. Eventually, heavy vibration dampeners were attached to the dispenser. In general, however, the meters have proven extremely reliable.

There was also some experience with voltage fluctuations producing errors in the numbers shown on the Krause calculating head. In addition, the lack of a deliberate reset switch, turning the head off and then on again for each separate fuelling cycle, sometimes caused errors to be generated (the dispenser, unlike a gasoline pump, does not have a pump motor); this switch was added soon after the original installation.

In early January, 1985, a small problem with a loose cam on the end of the actuating arm resulted in intermittent gas flow shutoff at the dispenser. The unit was readjusted and tightened. However, a small number of customers either received more gas than they actually paid for or were inadvertently prevented from refuelling from one side of the dispenser.

The meters have been checked by the Weights and Measures Division of Consumer and Corporate Affairs on a regular basis and have consistently exceeded their minimum requirements for use in custody transfer.

EXHIBIT 11 - NATURAL GAS DISPENSER


INLAND NATURAL GAS VEHICLE FUEL
23.9
PER LITRE EQUIVALENT
NATURAL GAS-VEHICLE FUEL
CUSTOMERS WISHING TO SELF SERVE WITH NATURAL GAS MUST
BE QUALIFIED FOR SELF SERVICE BY MOHAWK TRAINING STAFF.
MOHAWK STAFF WILL ASSIST ALL OTHERS FOR REFUELING.

"Breakaway" Fittings

Since the shut-off valve for the high pressure gas flow is located at the end of the high pressure fuelling hose, there has always been a safety-related concern for the escape of gas should a vehicle drive away with the fill nozzle still in the vehicle receptacle. Inland had made two separate efforts to install "breakaway" devices on the fuelling hoses, with the objective of having the dispenser end of the hose separate from the dispenser, and shut off the flow of gas, should the hose be subjected to an unusual pull.

The first "breakaway" device involved the use of a Hansen quick disconnect fitting, together with a cone-shaped tower around the inner nine inches of the hose to provide leverage to disconnect the fitting with a pull from the side. A chain restrained the tower from flying too far when it did come off. The hose came out of the top of the dispenser, and the tower pointed up. When these were first tried during the winter of 1983-84, two problems emerged:

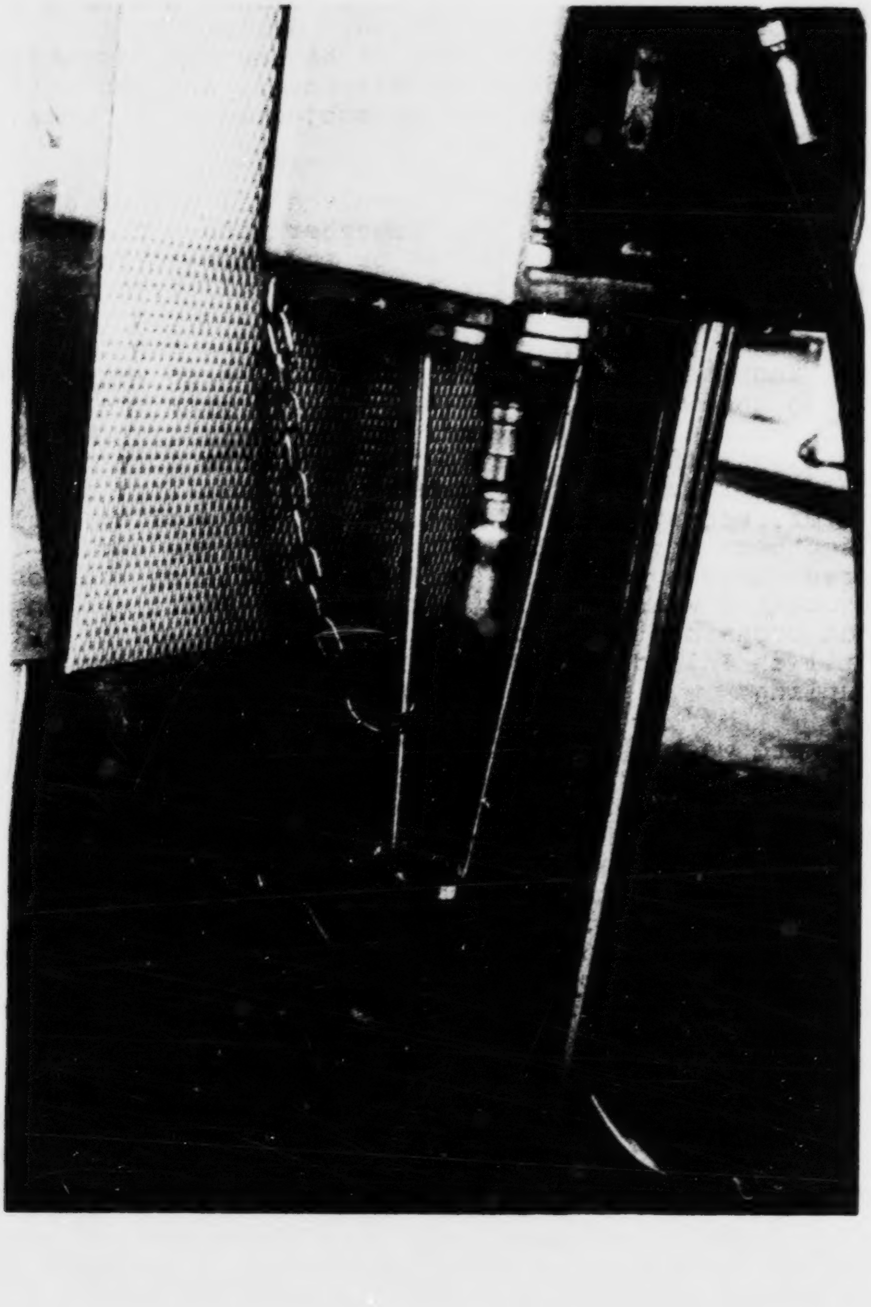
- the higher the pressure in the hose, the more force would be required to disconnect the coupling; in winter, pressures were lower, and the coupling would disconnect more easily. This was occurring two or three times a day, from the normal pulls on the hose associated with fuelling a variety of vehicles. On each occasion that side of the dispenser was disabled until an Inland serviceman arrived to reconnect the coupling.

- if there was any moisture in the gas, freeze-offs would occur in the couplings. The couplings must then be blown down, thawed out, and dried, before any further fuelling can take place.

Currently, a new "breakaway" device is being tested, but has yet to be tried in severe winter weather. This includes a longer fuelling hose (16 feet rather than 11 feet), a hose retractor to take some of the tension off the breakaway tower, which now comes out of the side of the dispenser and points down, and a Parker quick disconnect coupling. An illustration of this device is shown as Exhibit 12. During the summer of 1985, few problems were experienced with accidental breakaways, but these do seem to be increasing as the weather becomes colder, and fill pressures become lower; no freeze-offs have yet occurred.

In the almost three years that this dispenser has been in use, there has not been an incident where a customer has attempted to drive away with the refuelling hose still connected to the vehicle.

EXHIBIT 12 - CURRENT "BREAKAWAY" DEVICE FOR FILL HOSE



Fill Valves

A number of fill valve types have been used on the fuelling hoses. The original Superior multi-turn (5992AX3) valve was replaced with a Parker LPJ2 half turn model. Inland now uses a stainless steel Whitey Model SS-83XF4 half turn three way ball valve, with a stainless steel handle replacing the original plastic one.

Fuelling Probe O-Rings

It is well known that the current fuelling probe design has experienced major problems with the consumption of O-rings, particularly in cold weather. With ambient temperatures around -20 to -30°C, most materials seemed to lose flexibility; some would not compress enough to go into the fill port, and others would not expand enough to seal the fill port once they were inserted. Among the types tried were:

- Viton 70
- Viton 50 (Nitrile 7377)
- Buna 70
- Buna 90
- "Red" O rings (no other description available)
- Aeroquip P/N 22617-4

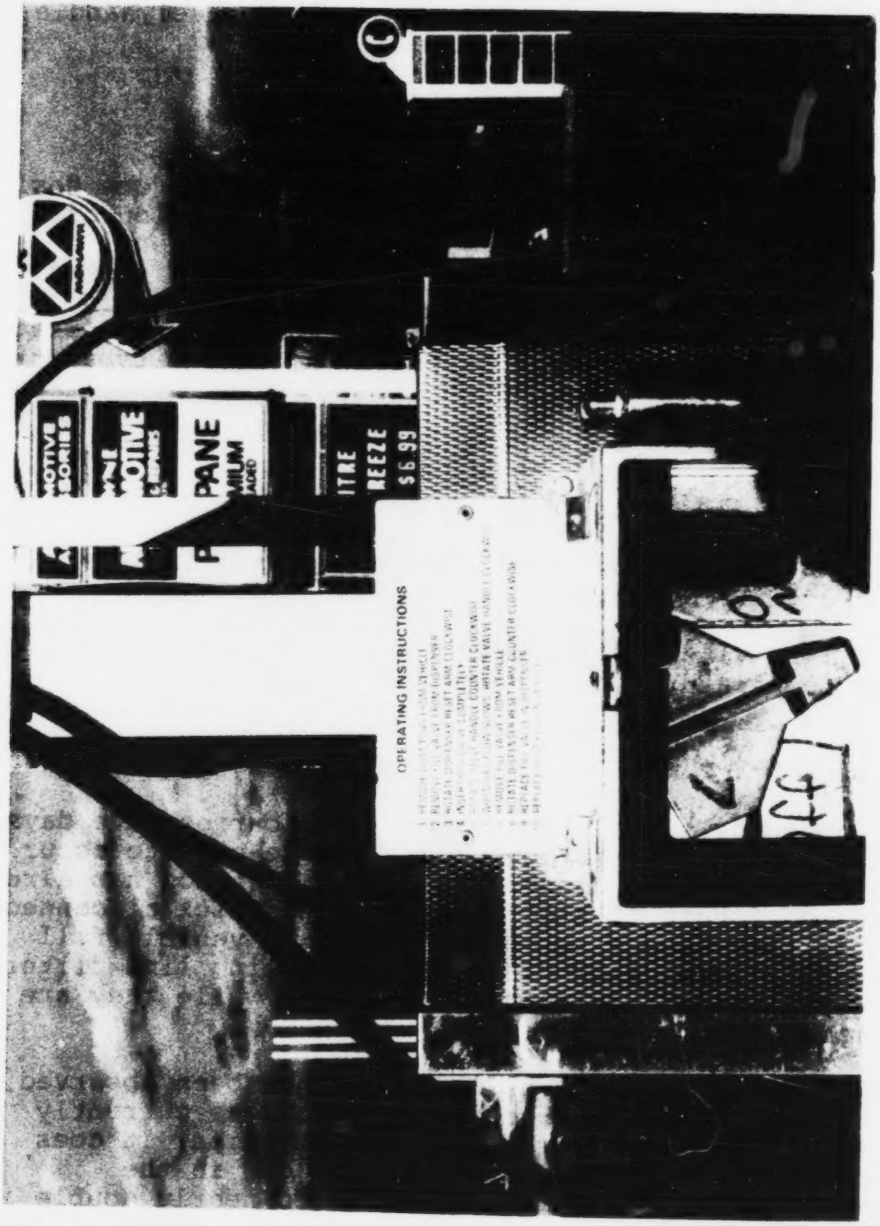
Of these, the Viton 70 appeared to be the best over a wide range of temperatures, but none were satisfactory.

Freeze-offs

Two or three times each winter, for four or five days each time, hydrate formation causes freeze-offs to occur at various points in the dispensing system. Mention has already been made of freeze-offs occurring in the quick disconnect couplings; they have also been observed in vehicle fill block check valves, fill valves, and fuelling line filters, and in first stage regulators of vehicles while they are being driven.

On a number of occasions when this has been observed, checks have been made on the dew point of gas currently being received from the Transmission companies. It does appear that the moisture content of the gas in the distribution system occasionally rises to nearly double its normal level of 2-3 lbs. per million cu. ft. This is thought to occur predominantly in the winter; no checks have yet been made in the warmer weather because the freeze-off problem has, of course, not occurred.

EXHIBIT 13 - DISPENSER OPERATING INSTRUCTIONS


OPERATING INSTRUCTIONS
PANE
$6.99

As a result, Inland has installed a molecular sieve gas dryer on the inlet side of the compressor. This should reduce moisture content to below 1 lb. per million cu. ft.

Self Serve Operation

Self-serve compressed natural gas fuelling was established at this station by September 1983, the first of its kind in Canada. The self-serve refuelling and user training procedures were the first accepted by the Ministry of Labour Safety Engineering Services Division and set the pattern for subsequent installations in B.C. Most natural gas stations now coming on stream in B.C. are designed to be self-serve.

Two Mohawk station personnel were certified by Inland as instructors. These people provided training and certification to drivers wishing to fill their own vehicles. Currently about 95% of all fuelling transactions at the station are on a self serve basis. Exhibit 14 shows a sample of the drivers' identification card and the instructions for self serve fuelling. A photograph of the instructions on the side of the dispenser is also shown as Exhibit 13.

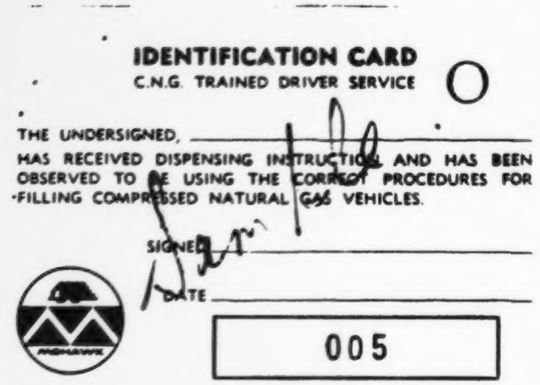
Additional Dispenser

Inland is presently installing an additional dispenser at a new pump island on the Mohawk site, in order to increase the capacity for natural gas fuelling. The dispenser will be essentially of the same type presently in use, with Micro-Motion mass flow meters and a calculating pump head. This dispenser should increase the capacity of the station to handle a vehicle population of up to 300.

The need for the additional dispenser is seen at those times of the day when a number of vehicles arrive simultaneously for fuelling. These times are typically 7:30 - 9:00 a.m., 11:30 a.m. - 1:30 p.m., and 3:30 - 4:00 p.m. These times no doubt reflect the predominantly commercial nature of the converted vehicle fleet.

The new dispenser will be in self-serve operation with a cardlok authorisation system. A revised plan of the station, with all planned new equipment shown, is included as Exhibit 15.

EXHIBIT 14 - SELF SERVE IDENTITY CARD AND PROCEDURE



IDENTIFICATION CARD

C.N.G. TRAINED DRIVER SERVICE

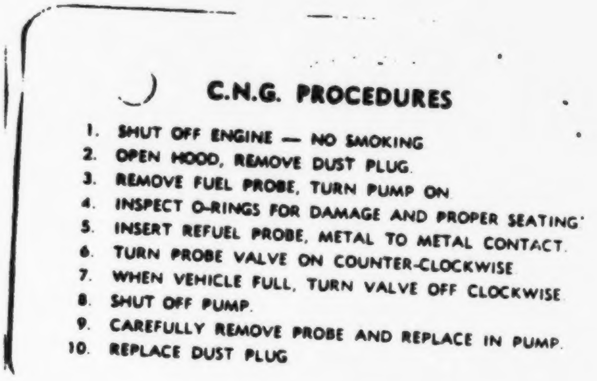
THE UNDERSIGNED, ______________________

HAS RECEIVED DISPENSING INSTRUCTION AND HAS BEEN OBSERVED TO BE USING THE CORRECT PROCEDURES FOR FILLING COMPRESSED NATURAL GAS VEHICLES.

SIGNED ______________________

DATE ______________________

005



C.N.G. PROCEDURES

1. SHUT OFF ENGINE — NO SMOKING
2. OPEN HOOD, REMOVE DUST PLUG.
3. REMOVE FUEL PROBE, TURN PUMP ON
4. INSPECT O-RINGS FOR DAMAGE AND PROPER SEATING
5. INSERT REFUEL PROBE, METAL TO METAL CONTACT.
6. TURN PROBE VALVE ON COUNTER-CLOCKWISE
7. WHEN VEHICLE FULL, TURN VALVE OFF CLOCKWISE
8. SHUT OFF PUMP.
9. CAREFULLY REMOVE PROBE AND REPLACE IN PUMP.
10. REPLACE DUST PLUG

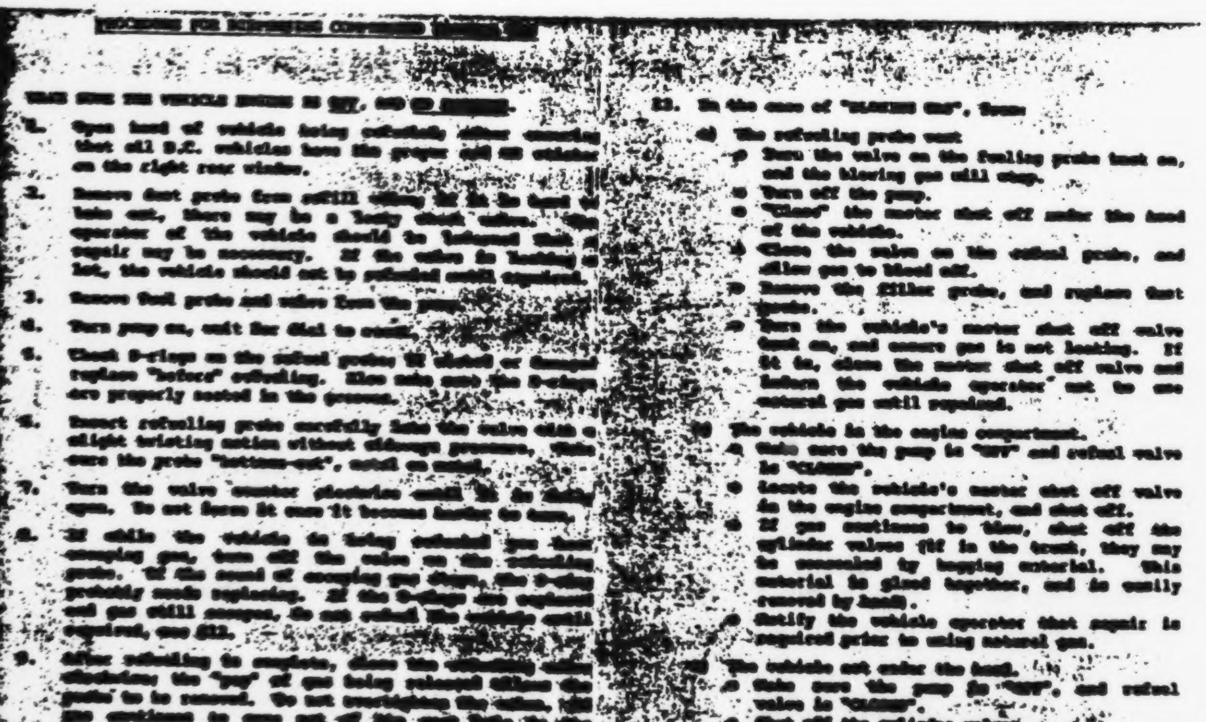
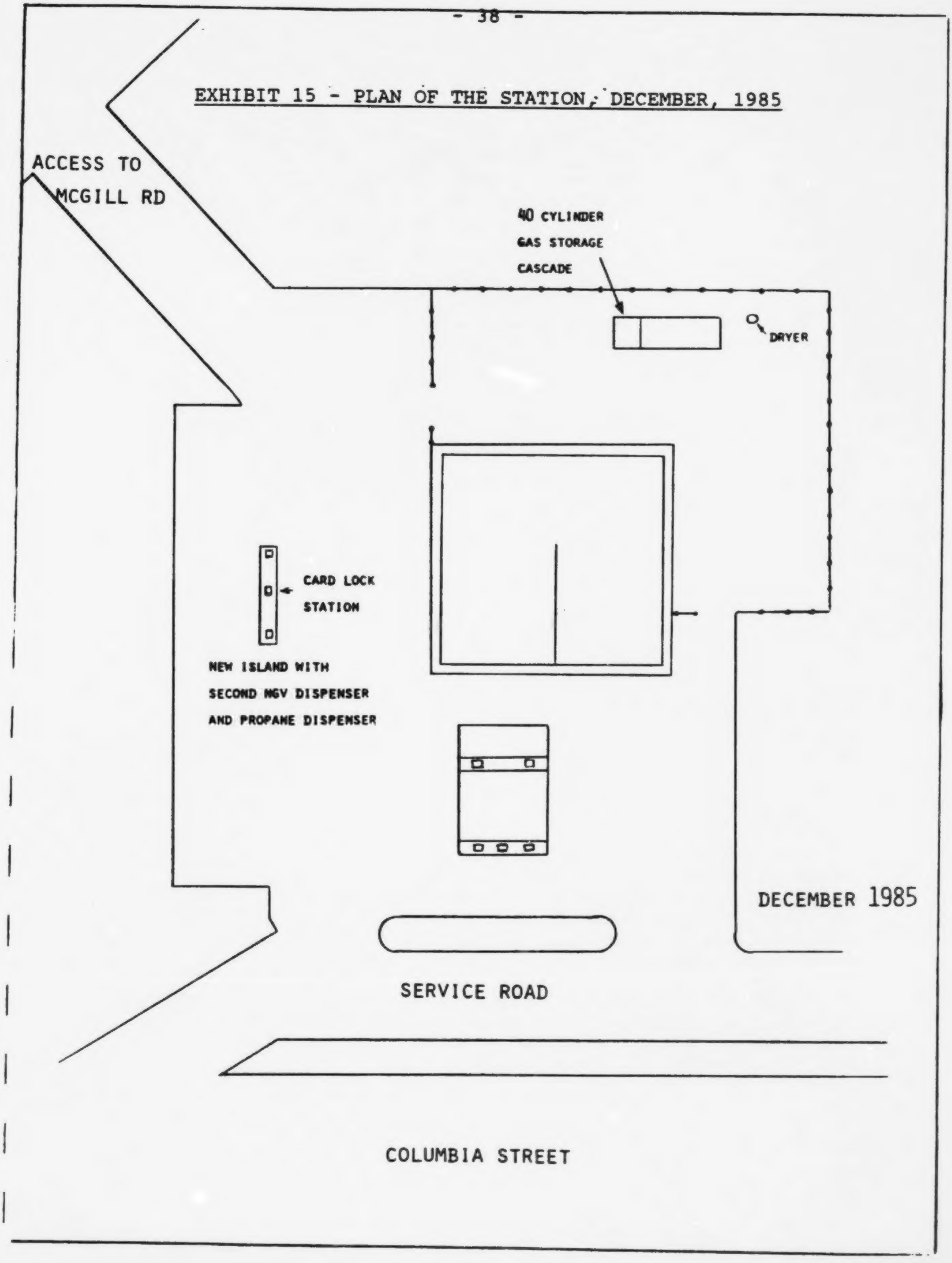


EXHIBIT 15 - PLAN OF THE STATION, DECEMBER, 1985


ACCESS TO
MCGILL RD
40 CYLINDER
GAS STORAGE
CASCADE
DRYER
CARD LOCK
STATION
NEW ISLAND WITH
SECOND NGV DISPENSER
AND PROPANE DISPENSER
DECEMBER 1985
SERVICE ROAD
COLUMBIA STREET

Safety

As noted earlier, the installation was equipped with Emergency Shut Down switches on the face of the building and near the cashier's position. This switch was actuated on a number of occasions by pranksters, but such incidents ceased with the installation of a breakable glass cover over the switch.

Other incidents reported include:

- a number of gas escapes due to inflexible or worn fill probe O-rings (see earlier section on O-rings)
- one or two gas escapes due to freeze-off of the check valve in the vehicle fill block; the result of this is that gas is vented from the vehicle after the fill probe is removed (see earlier section on freeze-offs)

No further safety concerns have been reported.

FUELLING STATION ECONOMICS

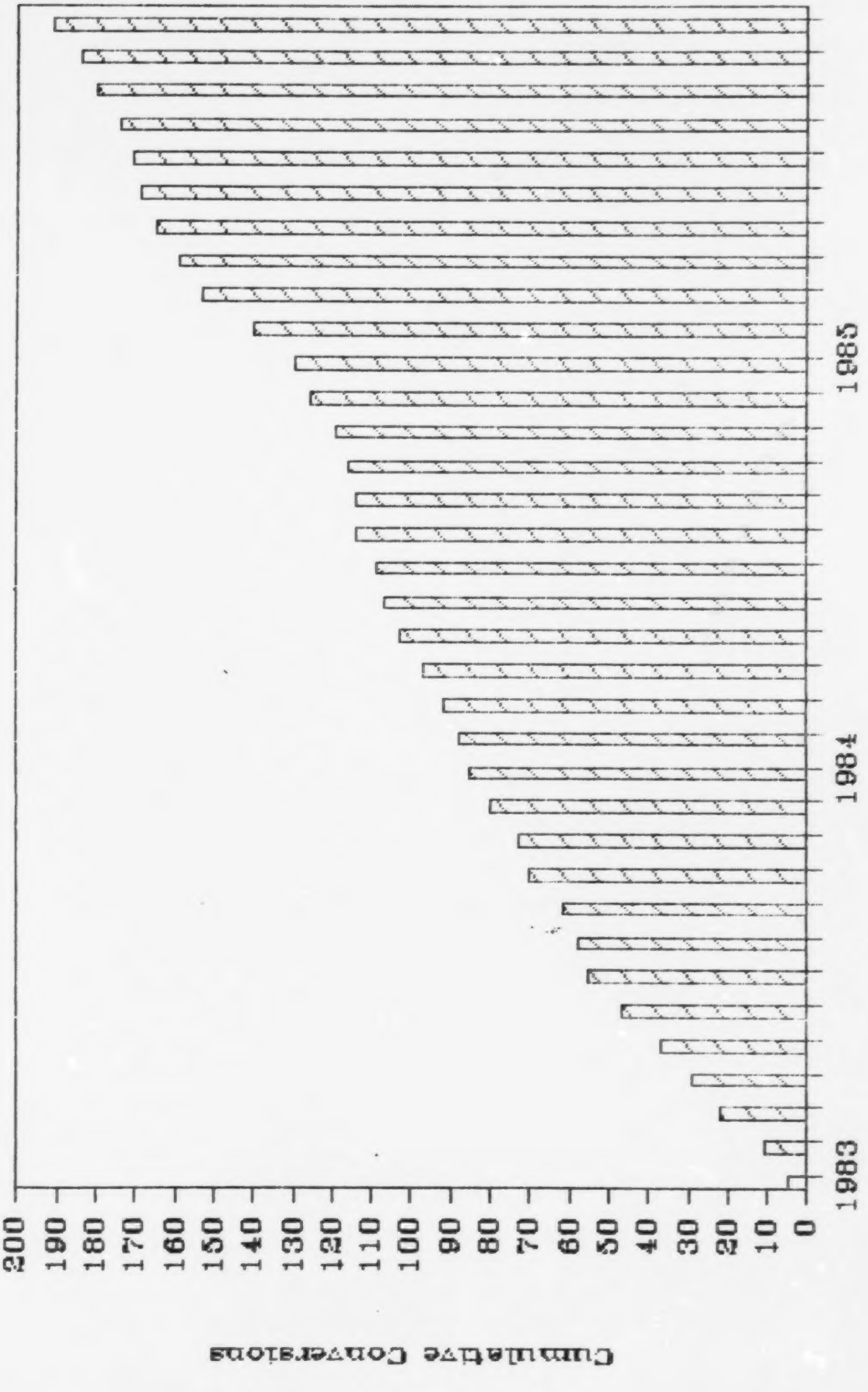
The initial capital cost of the natural gas fuelling installation at the Mohawk Sahali station was $285,964. The Federal Government provided a grant towards this of $40,000, resulting in a net total of $245,964 initial investment. It is presently contemplated that the addition of a molecular sieve dryer, the upgrading of high pressure storage controls, and the addition of a second dispenser, cardlok equipment, and associated piping will cost a further $73,580 before the end of 1985.

Gas Sales

The gas sales at the station have steadily increased since its opening in early 1983, reflecting continuing growth in the Kamloops natural gas vehicle fleet, which now (November, 1985), numbers 191 vehicles. The monthly gas sales are shown in Exhibit 8. Exhibit 16 shows the number of natural gas vehicles in Kamloops each month.

There is increasing congestion at the dispenser, and new conversions continue to be added at the rate of about 10 each month. This is what has brought on the need for a second dispenser at the station.

EXHIBIT 16 - KAMLOOPS NATURAL GAS VEHICLE POPULATION



Operating Costs of the Compressor

The service and repair costs for the compressor continue to be excessive. Although current service costs reflect an increased proportion of preventive maintenance, and some major parts replacement costs are covered by the manufacturer of the compressor, these costs are not decreasing. Exhibit 17 shows the compressor operating costs per litre from a few months after station startup.

Profitability of the Station

Exhibit 18 shows the profitability picture for the station, for three years' operation from start; the figures for 1985 are estimated on the basis of known figures for the first ten months.

While the station is now making a net profit, and the return on the original capital investment will average 7.3% over the three year period, it is prevented from reaching the utility's hurdle rate of return by excessive equipment maintenance and operating costs. If these were halved, the rate of return for the current year would be 17.7%. It should also be noted that very substantial payments are being made to Mohawk for the operation of the fuelling station.

Other Costs Incurred in Kamloops

Inland has also incurred a number of other costs in the introduction of natural gas fuelling in Kamloops. These include promotion and advertising costs of some $89,200, mostly incurred during the first two years (note that, despite a slowdown in active promotion of the fuel, new conversions are still coming on stream at a steady rate). Inland has also incurred a small net loss of about $10,000 over the three years in the wholesaling of conversion equipment to conversion shops.

IMPLICATIONS FOR A CAPTIVE FLEET STATION

Inland's experience in introducing natural gas fuelling in a public setting in Kamloops has some interesting lessons for organizations contemplating the establishment of a fuelling station for their own vehicle fleet.

Obviously, many of the costs incurred by Inland would not apply to a privately operated fleet station. The high capital costs of the fuelling station must still be faced, but the capacity requirements, compressor sizing, and

EXHIBIT 17 - COMPRESSOR OPERATING COSTS PER LITRE

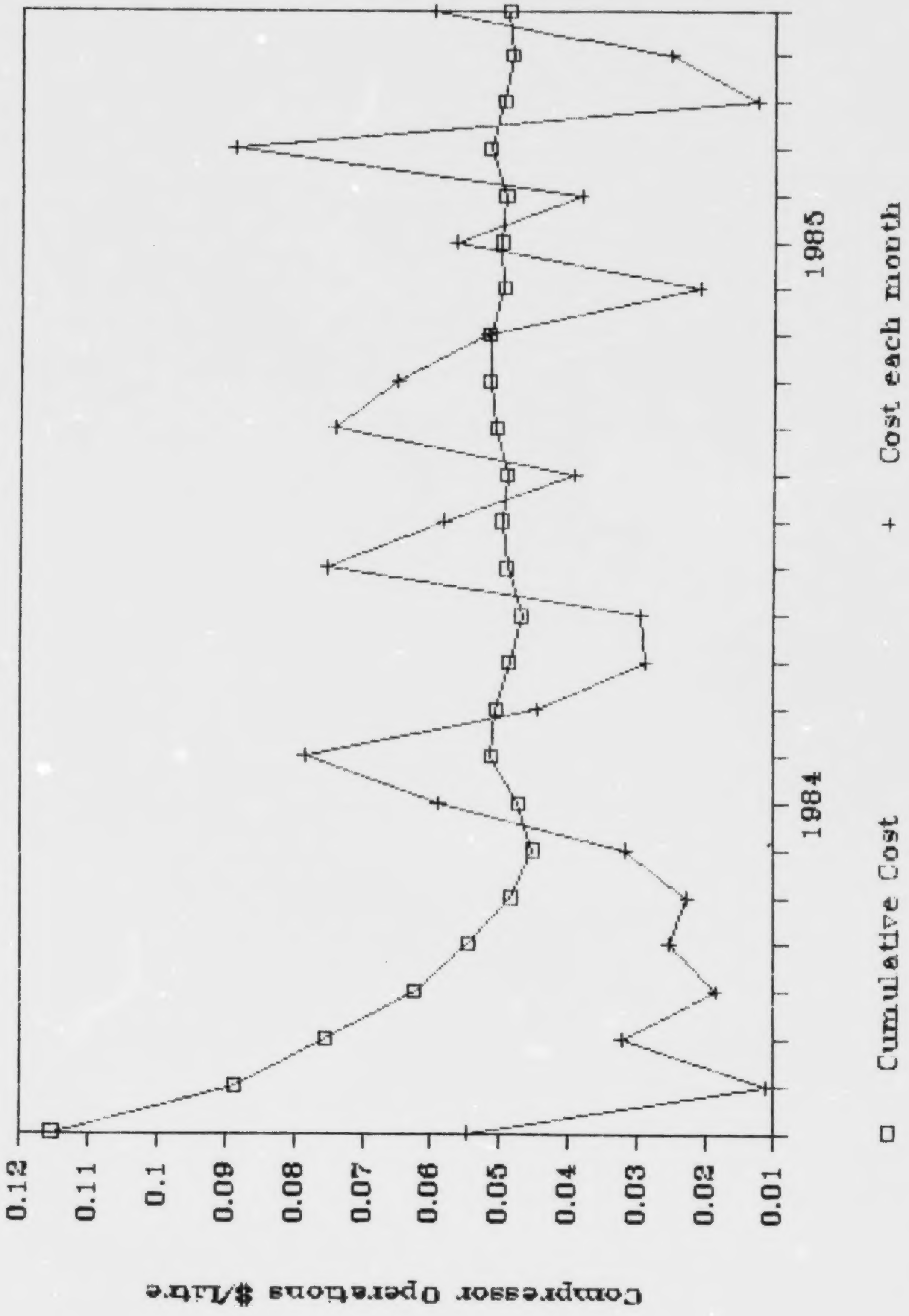


EXHIBIT 18 - STATION THREE YEAR PROFITABILITY

	1983	1984	1985(est.)	TOTAL
Gas Sales	$57,691	$134,669	$154,000	$346,360
Cost of Gas	$18,712	$41,007	$48,000	$107,719
Franchise Fee/Prop. Tax	$2,308	$5,387	$6,200	$13,895
Dispensing/Credit Fees	$23,966	$32,943	$41,000	$97,909
Maintenance Payroll	n/a	$8,538	$12,000	$20,538
Maintenance Parts	n/a	$5,564	$4,800	$10,364
Operations Payroll	$9,524	$10,987	$10,000	$30,511
Operations Miscellaneous	$3,657	$3,243	$3,500	$10,400
Net Revenue	($476)	$27,000	$28,500	$55,024

dispenser specifications can be explicitly determined; the number of vehicles and their fuel consumption is known and their percentage time on natural gas would undoubtedly be higher than for the Kamloops sample fleet.

It should thus be possible to calculate the economics of a fleet operation fairly accurately; there seems little doubt that the savings on natural gas fuelling for a large fleet of high mileage vehicles would provide a good return on investment. A review of the profitability figures for the public station indicates that, even making a reasonable allowance for staffing and servicing, and a 15% cost of capital, the cost of natural gas to company vehicles could be held under 20¢ per litre equivalent.

STATION CONSTRUCTION AND OPERATION SUMMARY

This section has described Inland's experience with nearly three years' operation of the first commercial NGV fuelling outlet in the B.C. interior. Despite very high compressor maintenance costs, the station is making a small profit, fuelling a diverse customer base of some 190 vehicles. The next section describes Inland's experience with the vehicles themselves.

SECTION 3 - CONVERTING AND OPERATING THE TEST VEHICLE FLEET

This section describes and analyses the results of operating the test fleet of some 50 varied vehicles over a period of approximately two years.

SELECTING THE VEHICLES

The objective of the program was to gather long-term data on the operation of a fleet of mid-size commercial vehicles over a considerable period of time. This fleet specifically excluded taxis, school buses, and private automobiles. Since no single fleet in Kamloops was large enough or would include an adequate variety of vehicles to serve the purpose, Inland's approach was to invite applications from the Kamloops area and select vehicles representing a cross-section of vehicle operators, including a substantial proportion of the Inland vehicle fleet.

Applications

Prospective participants in the vehicle fleet demonstration program were solicited through a call for applications, a copy of which is included in Appendix C. This application requested certain basic data on the vehicle, and also outlined the data collection and vehicle testing requirements for the program.

Response to this approach was very good, particularly considering the fact that these vehicles would be the first converted to natural gas in the area.

THE TEST FLEET

The resultant fleet of fifty vehicles showed a remarkable variety:

- there were 19 automobiles, 22 pickups, 6 vans, and 3 heavy trucks
- operators of the vehicles included the provincial government (9), city government (2), RCMP (3), utilities, including Inland (21), local artisans and businessmen (7), courier and delivery (7), and the local community college (1)
- the vehicles were powered by 36 eight cylinder engines, 13 sixes, and 1 four cylinder engine. Engine displacements ranged from 1.6 to 7.4 litres. The

average engine size was about 5.2 litres

- vehicle model years ranged from 1975 to 1984 (the test was started in 1983), with an average of 1981; scale weights ranged from 1040 kg. to 4560 kg., with an average of 2275 kg.

- at the start, all vehicles were well broken in, with a minimum mileage on converted vehicles of 10650 km. and a maximum of 99598 km. The average starting mileage was 52,000 km.

- use of the vehicles ranged widely, as can be seen from the variety of operators. Some vehicles were used very little, most on a daily basis, and a few (particularly courier vehicles) accumulated very large mileages. The average vehicle accumulated some 41,000 km during the test period.

- six of the vehicles were designated as control vehicles, not converted to natural gas, and run for comparison of gasoline mileage and repair costs.

In total, the converted vehicles accumulated nearly 2 million Km. during the test, of which 1.2 million km. was run on natural gas.

Exhibit 19 lists the fleet vehicles, along with their operators, engine specifications, scale weight, and natural gas cylinder capacity.

CONVERTING THE VEHICLES

Conversion of vehicles was first carried out in Kamloops in the conversion shop at the Mohawk fuelling station. Inland had leased this space from Mohawk, and re-leased it to Towne Automotive Ltd. Subsequently, conversions were also carried out by Northsyde Automotive and Syd Smith Chevrolet Oldsmobile.

Conversion shop personnel had been trained in a special Natural Gas Conversion Certificate course presented by the Pacific Vocational Institute in Vancouver, and financed primarily by the B.C. Provincial Government.

Inland itself took on the task of purchasing and warehousing the conversion equipment, and wholesaling it to certified installers only. In the spring of 1983, the company experienced considerable difficulty in purchasing such items as regulators, cylinders, and mixers, from all manufacturers.

EXHIBIT 19 - KAMLOOPS TEST FLEET, PAGE 1

License Number	Year	Make	Model	Owner	No. Cyl	Engine Disp. L.	Scale Wt. Kg.	NG Cyl L.
0075JV	1981	Dodge	Pickup	Inland Natural Gas	6	3.7	1940	86
1422FB	1980	GMC	Pickup	Government	8	5.7	2410	100
1988LD	1984	Chev	Pickup	Inland Natural Gas	8	5.7	2300	120
1989LD	1984	Chev	Pickup	Inland Natural Gas	8	5.7	2550	0
2784KX	1983	Chev	C-30	Inland Natural Gas	8	7.4	4560	180
3232KB	1981	Dodge	Van	A & A Boiler Service	8	5.2	2200	120
4347FR	1978	Ford	4X4	Towne Automotive	6	5.0	2381	120
4418GA	1980	Sier.	FlatDk	Inland Natural Gas	8	7.4	3490	180
4472GA	1980	Chev	Van	Inland Natural Gas	8	5.0	2460	120
4559LC	1982	Ford	Pickup	Kam. Indust. Express	8	5.0	2010	120
4560LC	1982	Ford	Van	Kam. Indust. Express	6	4.9	2110	120
4561LC	1982	Ford	Pickup	Kam. Indust. Express	6	4.9	1980	120
4647KV	1977	Ford	Pickup	D.L. Townsend Survey	8	7.5	3090	120
5297JK	1982	Ford	Van	Prestige Parcel	6	4.9	2070	120
5299JK	1982	Ford	Van	Prestige Parcel	6	4.9	2040	120
5447JL	1981	Int'l	Truck	Inland Natural Gas	8	5.7	6380	180
5469GL	1980	Chev	Pickup	Kam. Mechanical Cont	6	4.1	2240	120
5646JL	1981	Dodge	Pickup	Inland Natural Gas	8	5.2	2230	240
6533FL	1980	Ford	Pickup	City of Kamloops	6	4.9	2400	0
6534FL	1980	Ford	Pickup	City of Kamloops	6	4.9	2370	120
6783FL	1981	GMC	Van	Kamloops Bottling	8	5.7	2280	120
7058JG	1982	Dodge	4X4	Government	8	5.2	2380	100
7182HL	1978	Ford	Pickup	Rayleigh Renovating	8	7.5	2890	120
8116HL	1977	Ford	Pickup	Heritage Plumbing	8	6.6	3170	120
8280GF	1981	Dodge	Pickup	Inland Natural Gas	8	5.9	2730	120
8282GF	1979	Sier.	Pickup	Inland Natural Gas	8	5.7	2660	120
8283GF	1979	Sier.	Pickup	Inland Natural Gas	8	5.7	3629	0
8536KP	1983	Ford	Pickup	B.C. Bearing	6	4.7	1980	120
9695KF	1982	Dodge	Pickup	Inland Natural Gas	8	5.9	2370	120
9696KF	1982	Dodge	Pickup	Inland Natural Gas	8	5.2	2130	120
AAD526	1978	Plym.	Sedan	Government	8	5.2	1740	100
AAD564	1978	Plym.	Sedan	Government	8	5.2	1620	0
AAD573	1978	Plym.	Sedan	Government	8	5.2	1760	100
AAG903	1979	Ford	Sedan	Government	8	5.0	1790	100
ABF495	1980	Ford	Sedan	Government	8	5.0	1860	100
ABF497	1980	Ford	Sedan	Government	8	5.0	1870	100
ABF811	1981	Ford	Sedan	Government	8	4.2	1500	100

...continued on next page

EXHIBIT 19 - KAMLOOPS TEST FLEET, PAGE 2

License Number	Year	Make	Model	Owner	No. Cyl	Engine Disp. L.	Scale Wt. Kg.	NG Cyl L.
ACS414	1980	Chev	Sedan	B.C. Hydro	6	3.8	1660	120
ACS435	1980	Chev	Sedan	B.C. Hydro	6	3.8	1460	0
BVS247	1982	Dodge	Sedan	Inland Natural Gas	6	3.7	1700	86
CCW759	1980	Ford	Sedan	Inland Natural Gas	8	5.8	1980	60
CHG293	1983	Chev	Sedan	R.C.M. Police	8	5.0	1830	120
CHG294	1983	Chev	Sedan	R.C.M. Police	8	5.0	1810	120
CNGNO1	1981	GMC	Pickup	Northsyde Automotive	8	5.0	1840	120
EEF675	1983	Chev	Sedan	R.C.M. Police	8	5.0	1640	0
EPR241	1975	Buick	Sedan	Cariboo College	8	5.7	1860	120
GBX658	1980	Chev	Sedan	Inland Natural Gas	8	5.0	1650	120
HKL515	1981	Chev	H/B	Inland Natural Gas	4	1.6	1040	60
JDK472	1977	Chev	Sedan	Inland Natural Gas	8	5.7	1960	103
JDK478	1978	Pont	Sedan	Inland Natural Gas	6	3.8	1680	120

However, by August of 1983, some 63 conversions had been completed in Kamloops. Because of the interest of the company in the launching of NGV in the Kamloops area, and also in connection with the requirements of this contract, Inland became involved in the testing and tuning of the converted vehicles. Comments on conversions, of course, reflect experience with all of the Kamloops vehicles currently operating on natural gas, not just the test fleet.

Experience with 1983 First Generation Conversions

Kits from three manufacturers were used during 1983, as follows:

- Renzo Landi two-stage regulators with Garretson mixers
- Tartarini three stage regulators with mixers manufactured by Diversified Fuel Components
- Garretson regulators (first stage separate from regulator for stages 2 & 3) with Garretson mixers.

The first two combinations, however tuned, did not appear to supply enough gas for larger engines, and the resultant power losses were too severe to be tolerable in Kamloops' hilly terrain. As a result, the majority of the 1983 conversions (and those since) have been carried out using the Garretson equipment. Some development and modification of the Garretson equipment took place as the installers gained experience. More detailed accounts of experience with these kits will be found in Appendix A.

By mid-1983, the standard conversion kit was comprised of:

- Two steel cylinders (usually Faber), with separate shut off valves with integral burst discs
- stainless steel high pressure lines with Swagelok fittings
- a separate Hoke valve high-pressure shut off
- a Garretson control block with Nupro shut-off valve and burst disc
- a NZIG fuelling receptacle with check valve
- a water-heated Trulite first stage regulator
- a KV Garretson second and third stage regulator

- a Garretson mixer with power valve
- solenoids for shut off of natural gas and gasoline, with a Garretson solenoid control box
- an electrical switch for changing from natural gas to gasoline
- a dual curve ignition system
- a remote fuel (pressure) gauge

Of the 44 natural gas vehicles in the test fleet, 38 were equipped with essentially this kit. Three were equipped with Renzo Landi kits, and three with Tartarini kits.

VEHICLE PERFORMANCE

Vehicle performance is summarized under several headings:

- power
- fuel economy and dollar savings
- emissions
- hot and cold weather variations, including starting
- vehicle range on natural gas
- vehicle maintenance, including maintenance of the natural gas conversion equipment

The sources of this information include the records kept on the fleet, dynamometer and emissions tests, drivers' comments, and a variety of service records maintained by Inland and others.

The information presented under this heading draws mainly on our experience with the test fleet. However, in the case of fuel economy statistics, we have used a subset (some 36 vehicles) of the fleet whose drivers appear to have been faithful and accurate in reporting both natural gas and gasoline purchases, etc.

During our two years' experience, a number of vehicles were lost to the test because of mishaps, transfers, or because they had many different drivers, making reporting unreliable. (Formal data recording started in September 1983; the procedures used are discussed later in this report.) Of the 44 vehicles which started the test on natural gas, 8 failed to report sufficient reliable data to be included in this calculation. In addition, gasoline data for a further 7 vehicles shows inconsistencies and has been eliminated from comparisons of economy between fuels.

Power

Dynamometer tests were carried out during 1983 on a substantial proportion of the fleet. The results of these tests are shown in Exhibit 20.

These tests show clearly an average power loss between gasoline and natural gas of 11.7% at full throttle. For comparison purposes, one vehicle was tested both at Cariboo College and on the chassis dynamometer at BC Research's new facility in Vancouver; the results were comparable, suggesting that the readings from Cariboo College's dynamometer are reliable.

Driver reactions, with very few exceptions, were that their vehicles had less power on natural gas, and that this was noticeable in the hilly terrain around Kamloops.

A particular problem was encountered when a fleet of local school buses tried to convert to natural gas. A number of these were converted by the school district shop staff (although they were not included in the test fleet) and operated for several months on natural gas. Despite numerous efforts by other conversion shop and Inland personnel, the power developed by these large-engined vehicles was never satisfactory to their drivers, and the conversions were removed without the problems being solved.

Fuel Economy and Dollar Savings

As noted above, reliable natural gas consumption records were obtained for some 36 of the test fleet vehicles, but seven of these do not appear to have reported their gasoline consumption consistently. (This group included one vehicle that operated completely on natural gas, thus not recording any gasoline consumption and making comparison impossible.)

Calculations of dollar savings were made on the basis of a kilogram of natural gas being equivalent to 1.72 litres of gasoline. Using this assumption, the majority of vehicles showed the same, or slightly lower, fuel economy on natural gas as on gasoline. (See later in this report for a discussion of fuel energy equivalence.)

EXHIBIT 20 - DYNAMOMETER TEST RESULTS

					BHP		
Date of Test	Owner	Licence #	Engine	Conv.	Gaso.	N.G.	% Loss
March 8/83	Inland	JDK 472	350 Chev.	Garr.	86	78	9.3
March 21/83	Kam Bottling	6783 FL	350 Chev.	Garr.	100	90	10.3
March 31/83	B.C. Hydro	ACS 414	6 cyl.Chev.	Garr.	74	70	5.4
April 5/83	MOTH	AAD 526	318 Chrys.	Garr.	80	72	10.0
April 21/83	Inland	4472 GA	305 Chev.	Garr.	86	74	14.0
April 28/83	Towne	4347 GA	300 Ford	Garr.	72	62	13.9
	Cariboo	EPK 241	350 Chev.	Garr.	98	88	10.2
May 3/83	RCMP	CHG 293	305 Chev.	Garr.	100	88	12.0
May 13/83	MOTH	AAD 573	318 Chrys.	Garr.	86	76	11.6
May 18/83	Forestry	1422 FB	350 G.M.	Garr.	112	94	16.1
	Forestry	2058 JG	360 Chrys.	Garr.	104	92	11.5
May 24/83	RCMP	CHG 294	305 Chev.	Garr.	102	84	17.6
July 19/83	RCMP	CHG 293	305 Chev.	Garr.	100	88	12.0
Aug. 9/83	Owner	5647 JL	318 Dodge	Garr.	100	86	14.0
Aug. 30/83	Prestige	5297 JK	300 Ford	Garr.	75	68	9.3
	Prestige	5299 JK	300 Ford	Garr.	74	68	8.1
Sept. 8/83	Inland	5246 JL	318 Dodge	Tart.	80	68	15.0
Oct 12/83	Industrial	4560 LC	300 Ford	Garr.	64	60	6.3
Oct. 13/83	Industrial	4561 LC	300 Ford	Garr.	75	64	14.7
	Industrial	4559 LC	302 Ford	Garr.	68	60	11.8
Feb. 1/84	Inland	CCW 759	351 Ford	Garr.	76	66	13.2
					AVERAGE LOSS		11.7

EXHIBIT 21 - MONTHLY FUEL SAVINGS DISTRIBUTION

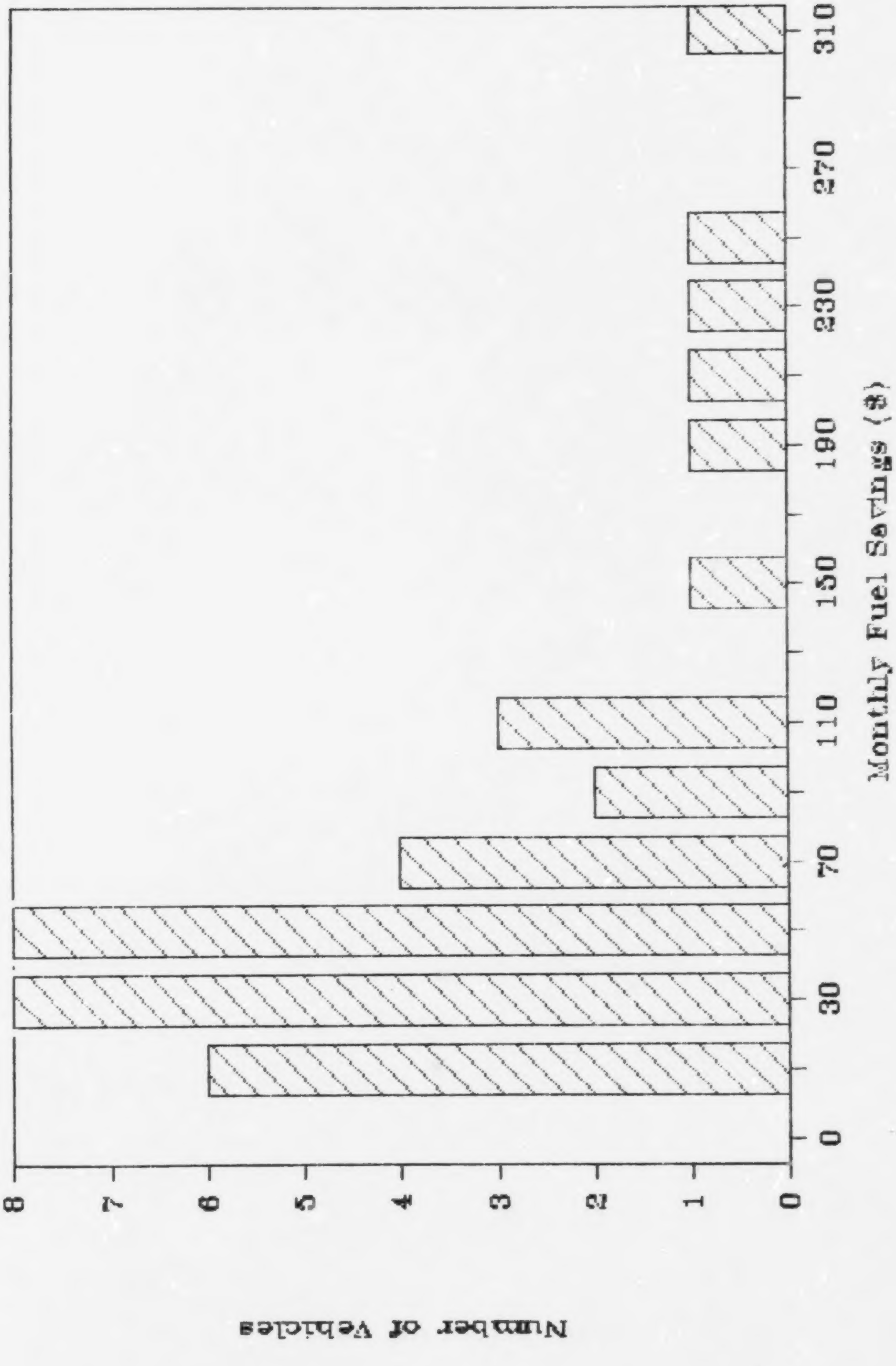


EXHIBIT 22 - FUEL ECONOMY vs. SCALE WEIGHT

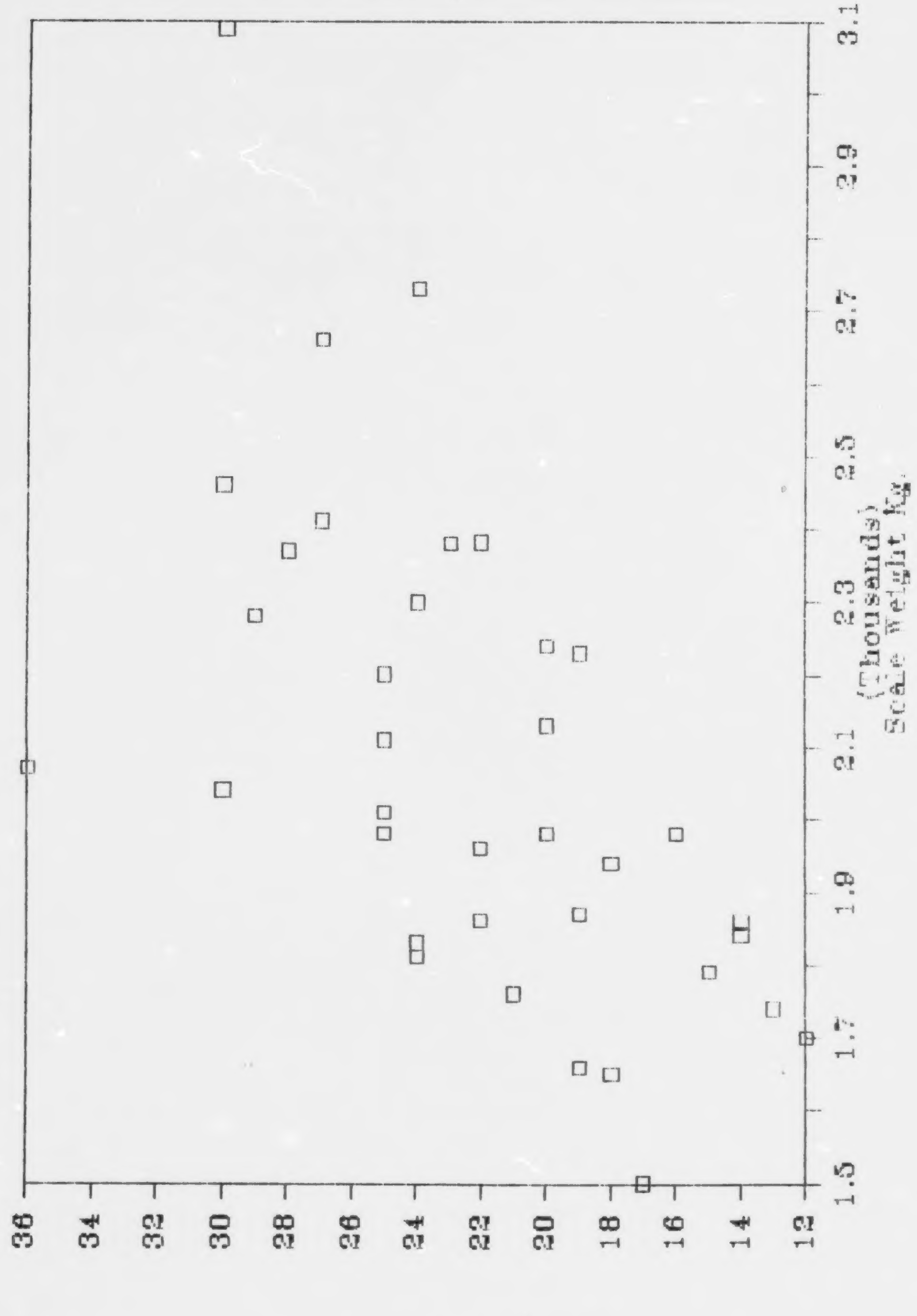


Exhibit 21 shows a distribution of monthly average fuel cost savings by vehicle. Generally, fuel economy is inversely proportional to the weight of the vehicle. Exhibit 22 shows this relationship for natural gas.

The gasoline economy obtained by the control vehicles was significantly better than that obtained by their equivalent vehicles in the natural gas powered sample, raising the possibility that the kits used resulted in lower fuel economy on gasoline. The sample is too small to be generalized, but as a matter of interest, the following are figures on four control vehicles, together with comparable natural gas fleet members.

Vehicle	Km.Recorded	1/100km Gasoline	1 equiv/100km Natural Gas
City of Kamloops Ford Pickups, 4.9 litre V-8's			
6533FL	31610	14	Control
6534FL	35240	25	28
Inland Natural Gas Sierra Pickups, 5.7 litre V-8's			
8283GF	35813	21	Control
8282GF	24988	25	27
B.C. Hydro Chevrolet Sedans, 3.8 litre V-6's			
ACS435	26875	10	Control
ACS414	30736	18	19
RCMP Chevrolet Sedans, 5.0 litre V-8's			
EEF675	70155	13	Control
CHG293	37330	17	24
CHG294	82559	20	24

These differences seem considerably greater than would be expected from previous experience. A maximum difference of 10% in gasoline fuel economy between converted and unconverted vehicles might arise from a mixer with rather poor airflow in gasoline mode, and some of these differences exceed this considerably. It is also possible that driving patterns could differ markedly between vehicles.

Drivers, of course, had no way of assessing the economy of their vehicles from day to day. Mainly, their comments centred on how fast the vehicles seemed to run out of natural gas. This related to cylinder capacity and fill pressure, as well as fuel economy.

Emissions

Emissions tests documented by Inland as part of this project indicate that reduced CO (typically by 60%) and HC

EXHIBIT 23 - EMISSIONS TEST RESULTS

										CO%------		HC ppm--		B.H.P---	
Date	Licence Number	Year	Make	Model	Owner	Engine	Conversion	Odometer Km.	RPM	CNG	Gasoline	CNG	Gasoline	CNG	Gasoline
29-Oct-84	CHG294	1983	Chevrolet	Sedan	RCMP	V8/5.0	Garretson	90297	750	0.00	0.00	150	200		
									2000	1.00	2.50	10	100	47	53
									2750	1.60	3.20	0	100	84	100
30-Oct-84	CHG293	1983	Chevrolet	Sedan	RCMP	V8/5.0	Garretson	81269	700	0.05	0.15	80	275		
									2000	0.90	0.30	100	100	49	56
									2600	2.00	3.00	90	150	84	97
30-Oct-84	EEF675	1983	Chevrolet	Sedan	RCMP	V8/5.0	None	115617	675		0.10		175		
									2000		0.05		30		49
									2897		3.50		225		88
23-Oct-84	ACS414	1980	Chevrolet	Sedan	BC Hydro	V6/3.8	Garretson	73002	925	0.36	3.56	217	235		
									2000	0.96	0.37	0	0	44	50
									2668	1.70	6.75	0	86	69	75
31-Oct-84	JDK472	1977	Chevrolet	Sedan	Inland	V8/5.7	Garretson	72352	800	0.50	1.15	200	130		
									2000	0.10	3.20	40	80	42	54
									2500	0.50	3.40	30	150	81	94
25-Oct-84	ACS435	1980	Chevrolet	Sedan	BC Hydro	V6/3.8	None	84482	800		5.36		419		
									2000		0.02		92		38
									2782		5.86		114		64
18-Oct-84	4560LC	1982	Ford	Van	KIExpress	6/5.0	Garretson	93746	600	0.50	1.20	100	185		
									2000	0.75	0.48	28	65	42	48
									2650	1.38	2.00	30	75	66	75
31-Oct-84	AAD573	1978	Plymouth	Sedan	Highways	V8/5.2	Garretson	110054	800	0.15	1.20	100	100		
									2000	0.12	0.20	110	50	46	59
									2450	0.19	3.10	105	170	70	80
26-Oct-84	6783FL	1981	GMC	Van	Bottling	V8/5.7	Garretson	136835	700	0.15	0.80	100	100		
									2000	0.89	1.10	50	90	50	60
									2850	1.30	0.80	50	50	90	100
29-Oct-84	5299JK	1982	Ford	Van	Prestige	6/4.9	Garretson	115209	750	0.10	0.20	60	170		
									2000	0.20	0.55	40	120	30	42
									2450	1.05	2.70	30	140	68	76
25-Oct-84	2058JG	1982	Dodge	4X4 P/U	Forests	V8/5.2	Garretson	41028	800	0.31	1.20	65	106		
									2000	2.02	0.14	106	130	48	52
									2947	2.23	3.57	98	225	84	98
22-Nov-84	5646JL	1981	Dodge	P/U	Inland	V8/5.2	Tartarini	108670	750	0.50	1.75	100	75		
									2000	0.75	6.75	150	210	49	56
									2400	1.00	6.50	155	350	75	86
04-Dec-84	EPR241	1975	Buick	Sedan	College	V8/5.7	Garretson	76748	600	0.50	0.40	140	130		
									2000	1.50	1.00	100	85	47	58
									2550	1.70	3.70	80	200	78	88
21-Nov-84	CCW759	1980	Ford	Sedan	Inland	V8/5.8	Garretson	86460	850	1.00	3.20	250	325		
									2000	0.30	3.00	50	150	50	60
									2300	1.20	3.50	50	150	76	85

emissions (typically by 30%). The detailed results are shown in Exhibit 23.

These results are typical of natural gas vehicles. Please note that the testing procedure used is unable to distinguish between types of hydrocarbons measured; the majority of HC emissions are however expected to be unburned methane.

Hot and Cold Weather Operation

Data was collected on the daily ambient temperatures during the test period, but no significant correlations between temperature and a variety of operating parameters were identified. However, the following should be noted:

- very hot and very cold weather caused significant variations in the fuelling pressure at the station, and apparently affected the quantity of gas that could be taken on by a vehicle. The reasons for this are discussed earlier in this report in the description of compressor operation.

- it has earlier been noted that cold weather, combined with moisture in the gas, caused "freeze-offs"' in the fuelling mechanism and sometimes in the check valve in the fuelling probe receptacle on the car. This phenomenon also occurred in the high pressure regulator on the car, particularly if the hot water heating of this item was inadequate.

- numerous complaints were received from drivers about starting; in the final driver survey, 69% of respondents stated that their vehicle did not start easily on natural gas. Most started on gasoline and then switched over. This problem appeared to exist all year round but was particularly severe in cold weather.

Exhibit 24 indicates that, for a typical vehicle, the % of operating time on natural gas did not vary significantly with daytime temperature. It does not appear that drivers drove less on natural gas in cold or warm weather.

EXHIBIT 24 - % TIME ON NG vs TEMPERATURE

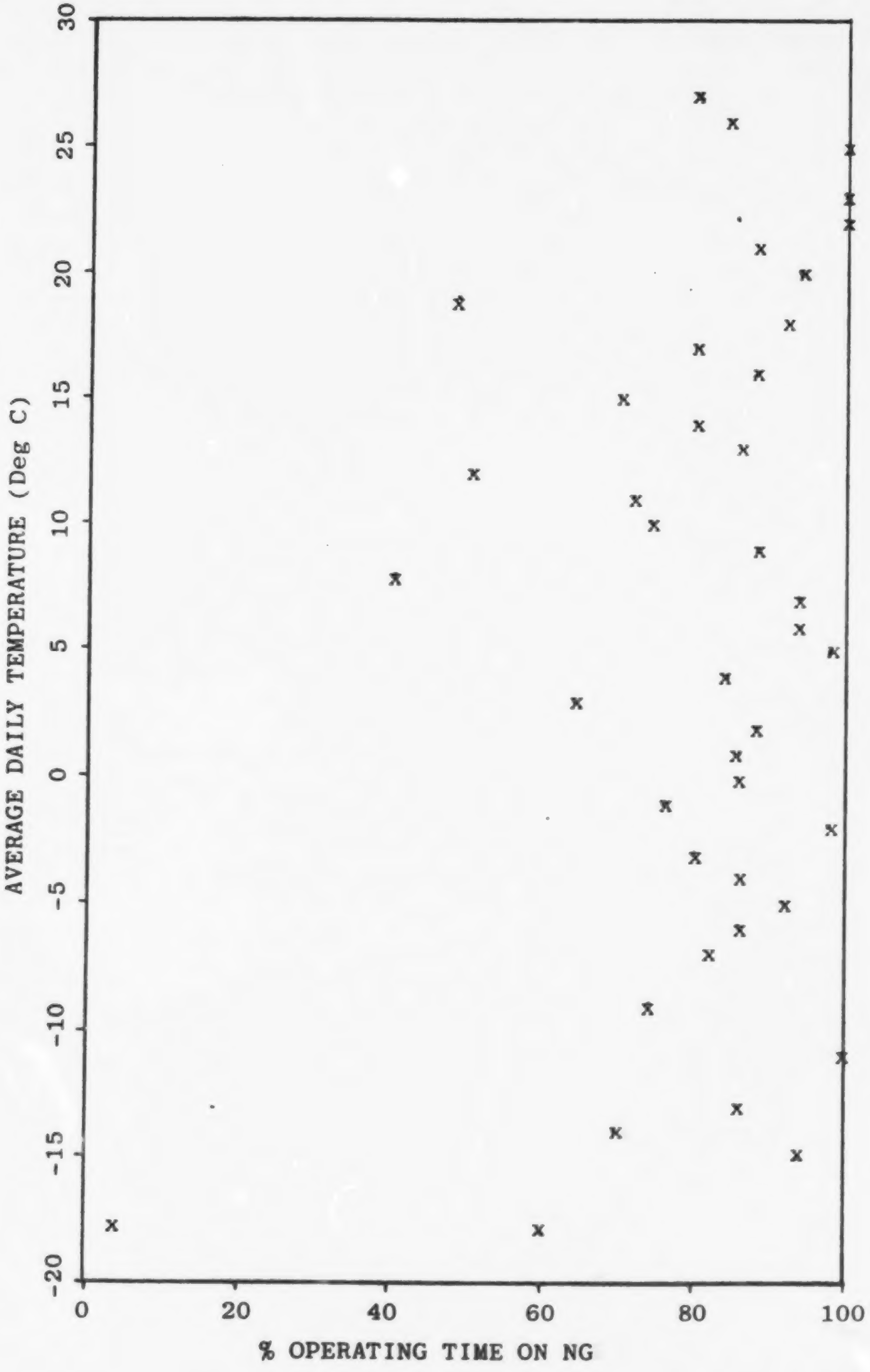
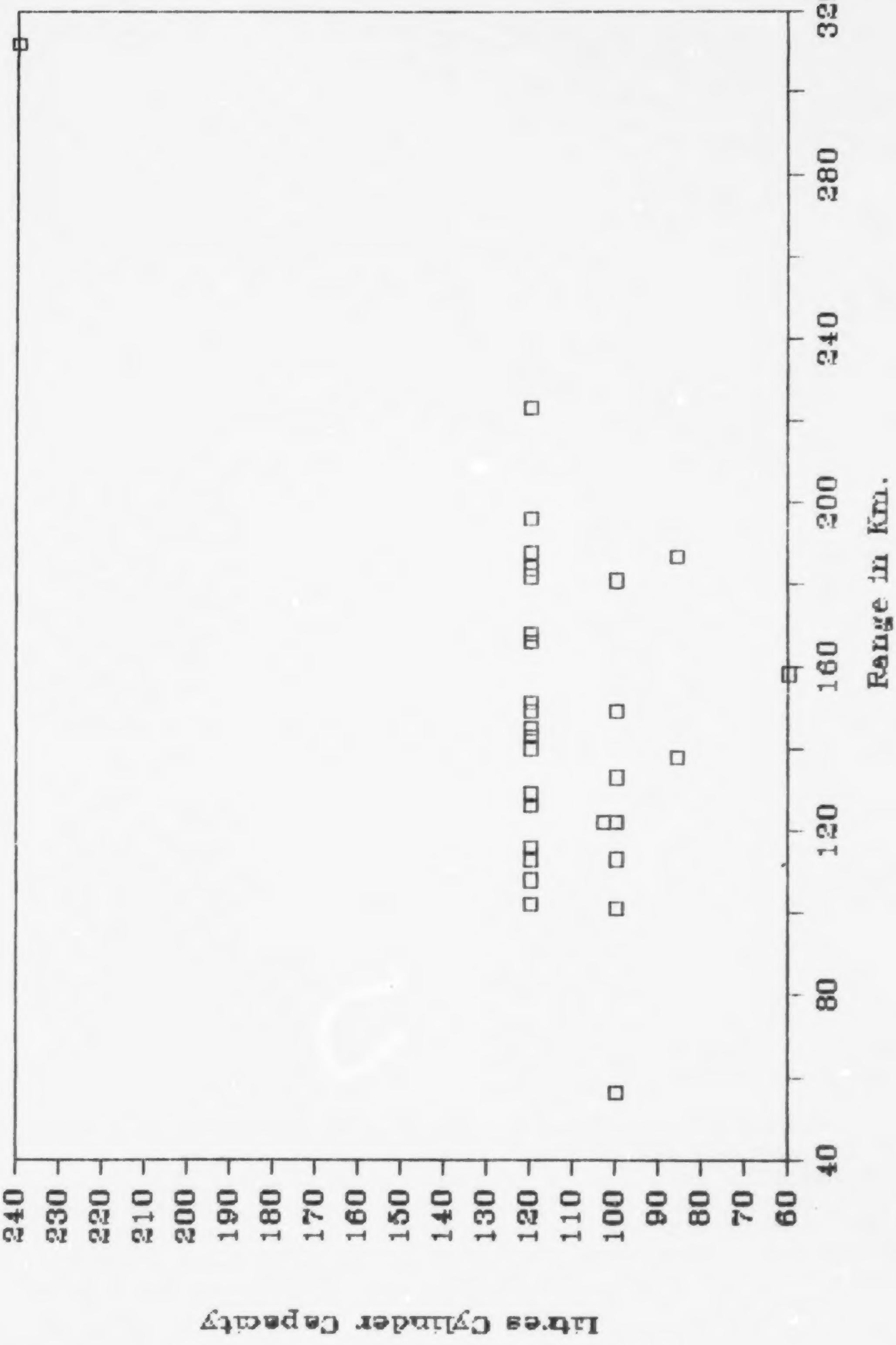


EXHIBIT 25 - RANGE vs CYLINDER CAPACITY



Vehicle Range on Natural Gas

By far the most frequent complaint about natural gas operation was related to the short range of the vehicle on natural gas, necessitating frequent refuelling visits to the Mohawk Sahali station. Exhibit 25 shows the average range between natural gas refuelling for all vehicles, together with their cylinder capacity.

It is apparent that many of the more heavily used vehicles had to fill up more than once a day. This became a major irritant when it is considered that the driver had to do this himself, and sometimes faced queues and delays if he arrived at the same time as other vehicles.

Only 6% of drivers reported that they never had to switch to gasoline to complete a shift; most said they "seldom" had to switch; 31% said they "often" had to switch. This result should be viewed in the light of how much of their total driving was done on natural gas. This will be discussed in more detail later in this report.

Vehicle Maintenance

It has been most difficult to maintain records which can be used to indicate clearly the effect of natural gas operation on maintenance costs. The best records of maintenance costs over the test period are Inland's, and these are shown by vehicle in Exhibit 26. These results are inconclusive; it is evident that any savings that may have occurred are obscured by other maintenance costs.

The recent driver survey indicated that a small majority of drivers felt that the amount of service work required had not changed significantly since before conversion. Many drivers felt that the need for service had increased, while only a small number felt that it had decreased.

Many drivers remarked that there seemed to be a lot of detailed tuning and adjustments required with the conversion equipment, and that this more than made up for any savings due to reduced plug changes, oil changes, etc. There was, in fact, no indication that any of these service items had in fact been reduced.

Inland was concerned enough about the maintenance needs of the natural gas conversion equipment to carry out a considerable amount of troubleshooting. Because Inland was stocking the equipment for the three conversion shops, and also to maintain the goodwill of the drivers who had undertaken conversions (not only those in the fleet test, but a total of about 180 in all), the company undertook the

EXHIBIT 26 - MAINTENANCE COSTS - INLAND VEHICLES

Type of Vehicle	Unit No.	NGV Cost/Km	Gasoline Cost/Km.
Chevrolet Malibu Sedan	146		$0.0508
	153	$0.0602	
	169	$0.0631	
	172		$0.0606
Chevrolet 3/4 T. Pickup			
	230		$0.0298
	253		$0.0262
	295	$0.0441	
	297	$0.0396	
Dodge 1/2 T Pickup			
	207		$0.0420
	276	$0.0307	
	277		$0.0732
	278		$0.0481
	282	$0.0399	
	289	$0.0188	

task of identifying problems with the equipment and working with the suppliers and conversion shops to overcome them.

A detailed description of these problem areas, complete with illustrations, will be found in Appendix A.

In summary, Inland feels that the reliability and performance of the conversion equipment is much improved from early 1983, thanks to the efforts of the manufacturers and conversion shop mechanics, not to mention the troubleshooting work carried out by Inland's own employees. However, there is still a great deal of work to be done to develop simple, trouble-free, efficient conversions. These are essential if natural gas for vehicles is to penetrate the motor fuel market in a significant way.

Engine Wear

Inland arranged to have lubricating oil analyses carried out on a number of the participating vehicles. The samples were analysed by Wear Check Canada Inc. of Toronto. The summarized results of these tests are shown in Exhibit 27.

In the initial tests, of the 21 vehicles exhibiting abnormal oil conditions, eight (including one unconverted control vehicle) were traced to dirt contamination, three showed excessive general wear for no obvious reason, two indicated antifreeze contamination, and seven (including three unconverted control vehicles) showed above normal bearing wear rates.

Fourteen of the vehicles were selected for further testing after an oil change period. Of these, seven vehicles had abnormal oil conditions, one showed excess engine wear for no apparent reason, two had antifreeze contamination and four (including one unconverted control vehicle) had signs of excessive bearing wear. All vehicles described as having engine wear rates above normal for no obvious reason were those owned and operated by courier services and travel from 48,000 to 72,000 km/year.

SAFETY

All vehicles converted in Kamloops followed the requirements of all applicable regulations, including a couple of running changes introduced after the program started. On the conversion kits, a couple of problems emerged:

- the Nupro "plug" valve attached to the control block on the Garretson kit was found to be unsuitable for

EXHIBIT 27 - OIL TEST RESULTS - PAGE 1

LICENCE #	ALUMINUM	BORON	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MOLYBDENUM	NICKEL	SILICON	SILVER	TIN	SODIUM	ZINC	VISCOSITY	SLUDGE	DIELECTRIC
4559LC	24	1	33	103	308	1000	74	17	3	11	1	14	23	1430	32	N	+ 9
Second Sample	9	10	7	94	82	790	136	1	2	12	1	4	145	934	24	N	+ 3
4561LC	44	2	24	30	290	1000	137	1	3	11	1	16	219	1126	19	N	+ 2
4560LC	24	7	48	72	255	876	398	1	3	14	1	20	95	1322	24	N	+ 4
Second Sample	39	2	46	33	233	1000	81	1	2	35	1	20	76	1003	26	N	+ 3
6534FL	28	7	35	50	151	1000	455	1	2	22	1	13	19	1989	25	N	+ 4
Second Sample	4	93	4	120	27	623	397	1	2	8	1	3	4	993	16	N	+ 1
6533 FL-C	6	19	5	91	41	226	595	1	2	5	1	4	5	1056	18	N	+ 2
Second Sample	3	101	1	117	20	67	475	1	3	4	1	2	2	996	17	N	+ 3
ACS-414	24	1	5	4	285	110	111	24	3	36	1	8	10	1407	20	N	+ 6
Second Sample	8	2	1	3	109	43	249	6	3	25	1	3	316	387	20	N	+ 3
ACS-435 -C	8	65	2	106	68	65	475	5	2	13	1	3	57	797	18	N	+ 1
CHG-294	5	28	3	98	31	5	512	1	2	7	1	4	12	1077	20	N	+ 1
Second Sample	6	4	1	13	27	1	283	1	2	7	1	3	371	953	25	N	+ 2
CHG293	4	37	2	36	29	8	420	1	2	6	1	3	10	987	28	N	+ 1
EBF-675-C	4	23	3	111	43	112	627	7	2	10	1	4	22	1067	22	N	+ 2
Second Sample	8	7	2	23	37	55	91	1	1	15	1	5	17	1072	23	N	+ 6

* Note - Underlined values indicate abnormally high amounts.

EXHIBIT 27 - OIL TEST RESULTS - PAGE 2

LICENCE #	ALUMINUM	BORON	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MOLYBDENUM	NICKEL	SILICON	SILVER	TIN	SODIUM	ZINC	VISCOSITY	SLUDGE	DIELECTRIC
5299JK	30	1	12	5	232	668	357	1	3	10	1	5	454	1097	23	N	+ 2
Second Sample	16	2	5	4	79	1000	230	1	2	11	1	3	338	949	23	N	+ 2
5297JK	17	1	8	8	244	510	273	1	2	16	1	5	449	970	22	N	+ 1
6783FL	7	18	3	53	71	1000	448	1	2	9	1	4	46	1650	23	N	+ 1
CNG-N01	7	1	5	3	92	1000	185	1	2	10	1	3	126	1660	29	N	+ 6
4347FR	6	1	1	4	47	100	341	1	2	13	1	3	337	945	18	N	+ 3
7182HL	16	16	8	10	206	1000	624	11	2	12	1	8	26	1363	26	N	+ 4
8116HL	66	24	13	55	673	1000	146	18	3	34	1	17	577	930	33	A	+ 5
EPR241	20	11	12	5	93	1000	109	1	2	10	1	4	60	925	30	N	+ 1
4647KV	4	71	2	117	34	648	479	1	2	6	1	2	24	934	18	N	+ 1
Second Sample	6	68	1	102	53	724	421	1	2	11	1	2	167	120	23	N	- 1
3232KB	13	26	21	21	200	1000	490	1	2	12	1	10	92	1311	32	N	+ 12
5469GL	44	11	11	23	317	51	83	7	3	287	1	9	182	977	17	N	+ 1
Second Sample	15	49	2	11	80	8	47	1	2	71	1	2	143	1543	26	N	+ 2
8536KP	7	17	4	1	42	5	442	1	2	8	1	4	5	1466	19	N	+ 1

* Note - Underlined values indicate abnormally high amounts.

EXHIBIT 27 - OIL TEST RESULTS - PAGE 3

LICENCE #	ALUMINUM	BORON	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MOLYBDENUM	NICKEL	SILICON	SILVER	TIN	SODIUM	ZINC	VISCOSITY	SLUDGE	DIELECTRIC
AAD526	12	92	5	3	71	1000	531	1	2	12	1	4	30	995	18	N	+ 3
ABF497	15	83	3	28	73	748	494	5	2	13	1	10	25	903	23	N	+ 1
AAG903	11	82	4	2	32	1000	553	1	2	7	1	3	4	956	20	N	+ 2
ABF495	3	90	3	2	24	393	587	1	2	6	1	3	1	965	19	N	+ 1
AAD573	11	74	4	10	65	1000	592	1	3	11	1	4	6	1086	28	N	+ 1
ABF811	20	77	9	1	68	782	725	10	2	9	1	6	2	945	30	N	+ 3
AAD564-C	8	63	4	1	63	1000	666	1	2	7	1	3	3	991	26	N	+ 3
1422 FB	11	63	8	99	60	1000	715	11	3	10	1	7	2	1031	20	N	+ 1
Second Sample	6	13	3	30	42	1000	317	1	2	13	1	3	308	816	35	N	+ 2
7058JG	3	64	3	100	23	766	675	1	2	4	1	3	5	932	21	N	+ 1
Second Sample	5	16	4	30	39	1000	348	1	2	7	1	3	395	943	18	N	+ 2
BVS247	5	1	2	28	33	3	249	1	2	6	1	2	380	811	15	N	+ 1
JDK478	37	15	2	93	246	1000	572	6	2	19	1	5	317	1189	21	N	+ 3
Second Sample	35	17	1	80	172	1000	414	1	2	18	1	4	407	1148	23	N	+ 3
GBX658	9	2	19	32	177	1000	198	1	2	11	1	8	13	1104	15	N	+ 1

* Note - Underlined values indicate abnormally high amounts.

EXHIBIT 27 - OIL TEST RESULTS - PAGE 4

LICENCE #	ALUMINUM	BORON	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MOLYBDENUM	NICKEL	SILICON	SILVER	TIN	SODIUM	ZINC	VISCOSITY	SLUDGE	DIELECTRIC
HKL515	13	2	3	6	32	39	320	1	2	13	1	5	457	1232	13	N	+ 1
JDK472	19	1	9	7	109	7	22	1	2	13	1	4	17	935	15	N	+ 1
CCW759	60	13	8	28	595	279	257	21	3	39	1	29	146	1072	30	N	+ 4
0075JV	4	1	1	5	17	103	309	1	2	3	1	2	413	960	18	N	+ 1
5646JL	8	1	12	12	78	891	286	1	2	10	1	6	298	875	20	N	- 3
9695KF	6	36	8	70	49	1000	663	5	2	5	1	4	212	1042	23	N	+ 1
8280GF	23	1	11	5	103	1000	339	9	2	12	1	4	424	961	19	N	+ 2
1988LD	20	1	7	21	168	635	27	1	2	80	1	47	55	933	18	N	+ 2
8282GF	10	1	3	1	56	1000	302	1	2	13	1	2	395	932	16	N	+ 1
9696KF	20	1	5	3	73	11	255	1	2	13	1	11	386	989	18	N	+ 1
4472GA	23	7	4	3	98	29	258	7	3	20	1	5	342	1272	20	N	+ 1
2784KX	4	6	4	20	69	1000	314	1	2	10	1	5	408	924	20	N	+ 2
4418GA	20	7	19	28	200	1000	332	5	3	10	1	9	362	1239	17	N	+ 1

* Note - Underlined values indicate abnormally high amounts.

EXHIBIT 27 - OIL TEST RESULTS - PAGE 5

LICENCE #	ALUMINUM	BORON	CHROMIUM	COPPER	IRON	LEAD	MAGNESIUM	MOLYBDENUM	NICKEL	SILICON	SILVER	TIN	SODIUM	ZINC	VISCOSITY	SLUDGE	DIELECTRIC
5447JL	36	1	42	14	261	1000	232	1	3	39	1	18	384	1675	17	N	+ 3
8283GF-C	33	7	10	29	154	1000	383	7	2	28	1	5	429	1061	18	N	+ 3
1989 LD-C	15	12	9	48	225	1000	261	9	3	80	1	38	92	1091	20	N	+ 3

* Note - Underlined values indicate abnormally high amounts.

the operating temperature range to which it was being subjected. A leakage incident occurred in a vehicle converted by CNG Fuel Systems Ltd. in Calgary. While no such valve failures occurred in Kamloops, some 40 vehicles that had already been fitted with this valve were recalled and retrofitted with a suitable replacement. While this was being done, the reference pressure at the Kamloops station was temporarily reduced to 2400 psig.

- a release of gas and subsequent fire at the CNG Fuel Systems Ltd. conversion and training centre in Vancouver was traced to an improperly fitted burst disc fitting. The B.C. Department of Labour issued an advisory reminding installers of the need to have an individual shut-off valve on each storage cylinder. This had been standard practice in Kamloops, and no retrofits were necessary.

Three incidents were recorded involving Kamloops vehicles:

- the release of gas from a private individual's vehicle which was parked outside in Kamloops. This was traced to an improperly assembled Swagelok fitting. No ignition occurred, there were no injuries or damage, but the majority of the natural gas stored on board the vehicle was vented to atmosphere. Inland is now making pre- swaging tools and depth gauges available to installation shops for use as standard practice to ensure that Swagelok fittings are properly assembled.

- a head-on collision on November 6, 1984 involving one of the test vehicles, a 1982 Ford Econoline van, licence no. 4560LC. This vehicle, owned by Kamloops Industrial Express, a courier company, was severely damaged and will be replaced. No leaking of gas was reported and all underhood components, although dislocated, were undamaged and operable. No dislodging or movement of the NGV storage cylinders installed in the rear cargo space was observed. The owner advises that the conversion components will be removed and reinstalled on the replacement unit.

- another of the test vehicles, a 1983 Chevrolet Malibu RCMP car (CHG 293), was involved in a single vehicle accident on January 5, 1985. The vehicle rolled on its side then came to rest on its roof. No leaking of gas was reported and all NGV components were intact with the exception of the air/fuel mixer which was damaged beyond repair as the vehicle's hood was pushed downward. All conversion components except the mixer were to be removed and re-installed on the replacement unit.

Detailed reports on these last two incidents will be found in Appendix B.

PERFORMANCE OF SPECIFIC VEHICLE GROUPS AND DRIVER ATTITUDES

From a marketing point of view, one of the most important and interesting aspects of this fleet test was the problem of maintaining good relations with a wide variety of vehicle operators in the face of problems with both the fuelling system and the vehicles. The following few pages comment on a number of clearly identifiable groups of vehicles and their drivers, what performance and economy they obtained, what particular concerns they had, and what attitudes resulted.

First of all, Inland wishes to make it clear that the vehicle operators were a volunteer group, and Inland had expected at the beginning that natural gas fuelling was, at this stage, a new technique and that some problems would occur. Inland very much appreciates the assistance and patience shown by the operators throughout the test period.

It was apparent, almost from the very beginning of the test period, that there was going to be a great variation in the percentage utilization of natural gas from vehicle to vehicle. The eventual percentage utilization, taking into account only those vehicles which reported data faithfully, is illustrated by the distribution in Exhibit 28.

It also became clear, after a number of months, that some vehicle operators were losing their enthusiasm for natural gas; on the other hand, some were unflagging in their support. Exhibits 29 and 30 show two sample vehicles and illustrate these patterns. In addition, some vehicle operators had trouble with the time recording apparatus; and others ceased to turn in data sheets altogether.

At the time, Inland employees undertook to contact some of the "problem vehicle" operators and ensure that not only were their conversions returned to top operating condition, but that they resumed reporting their fuel purchases to the project.

It was found that a number of the vehicles had been getting very poor performance on natural gas, but that their operators had been reluctant or found it inconvenient to bring them in for adjustment. It was also apparent that workmanship on some of the early conversions had been at fault.

EXHIBIT 28 - % DRIVING TIME ON NG DISTRIBUTION

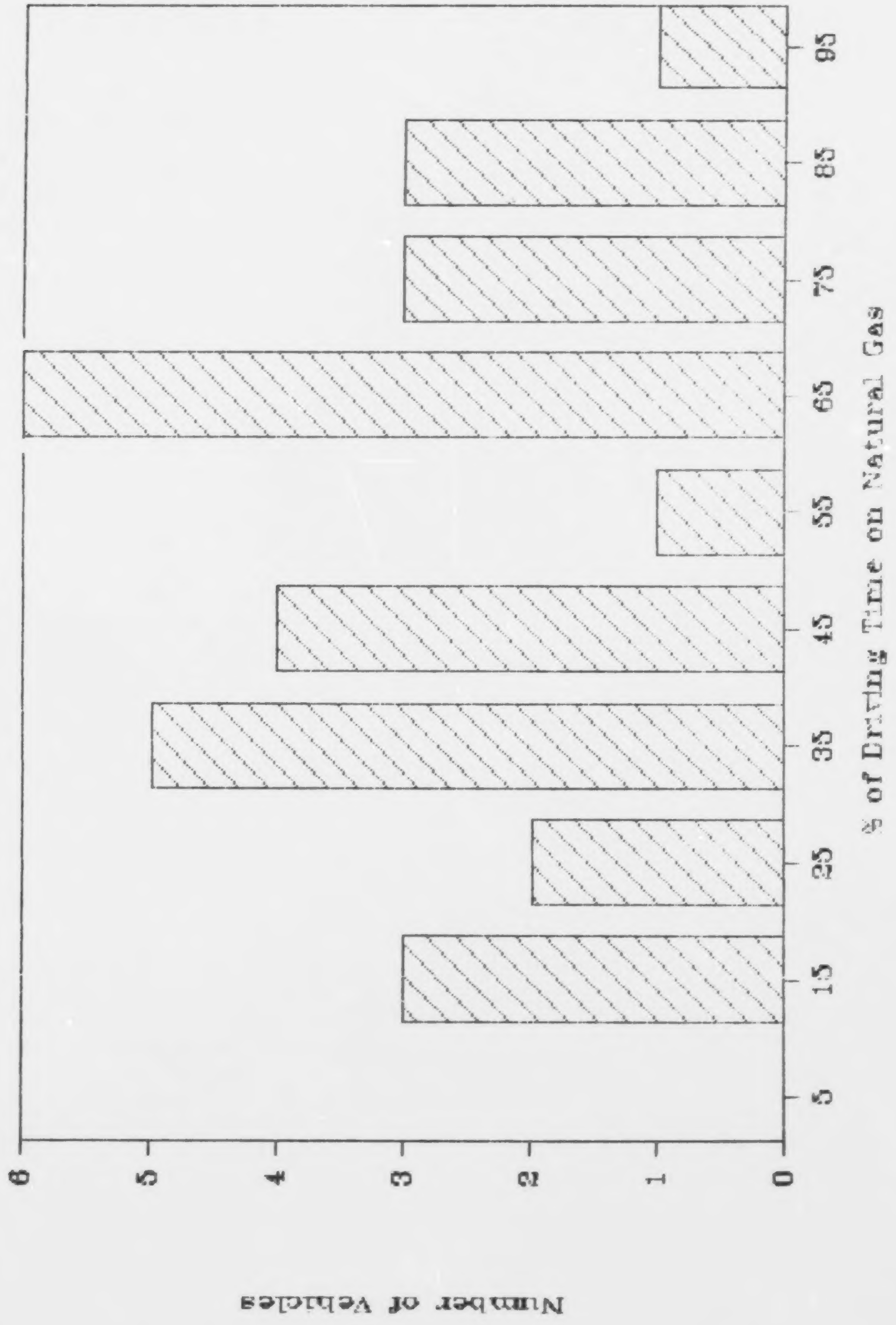


EXHIBIT 29 - % TIME ON NG - ENTHUSIASTIC USER

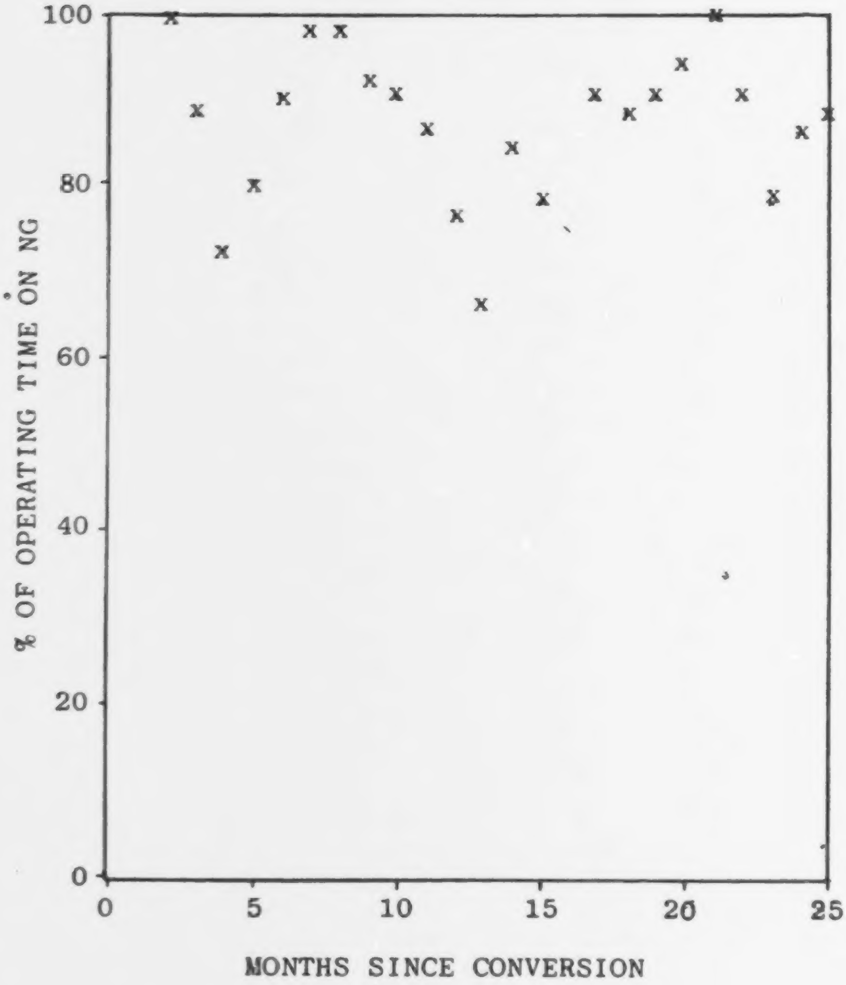
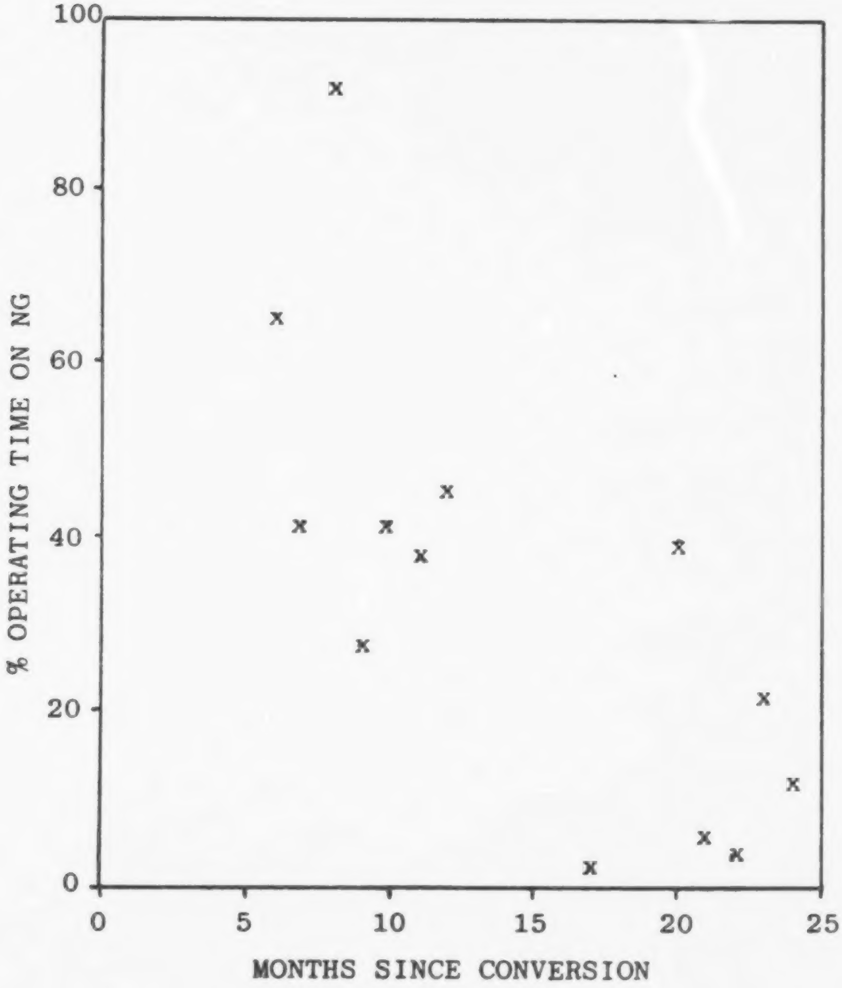


EXHIBIT 30 - % TIME ON NG - UNENTHUSIASTIC USER



Vehicle Operator Attitudes

In order to analyse vehicle operator attitudes, and assess their relationship to the "success" of the conversion, the results of the final driver survey were scored from the point of view of the attitude revealed through answers to the survey questions. These questions were concerned not only with opinion but also with perceived action; for example, one of the questions dealt with how much of the time the driver felt he drove on natural gas.

A summary of the attitude score, together with the calculated return on investment on the vehicle conversion, is shown for a variety of vehicles in Exhibit 31. Clearly, there is a close relationship between positive attitude (as shown by a plus number on the attitude scale) and high return on investment, but it is difficult to say which came first!

Exhibit 31 indicates that without a positive attitude towards natural gas, the driver will not achieve good results. However, unless the vehicle and its pattern of usage offer good potential for savings, even the most enthusiastic of drivers cannot achieve good savings.

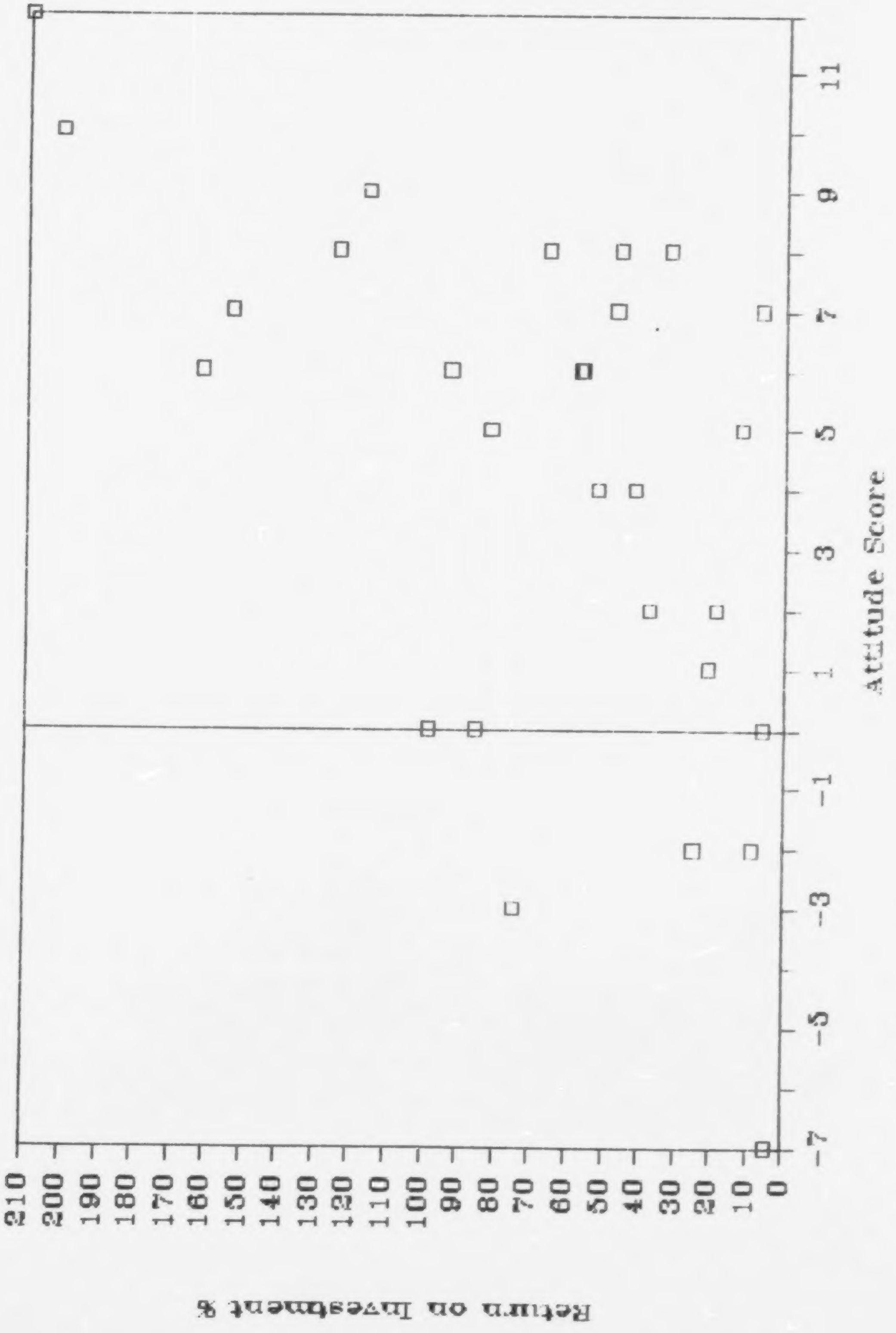
Analysis of Vehicle Groups

The analysis did highlight a number of vehicle groups which had varying degrees of success with their conversions. The vehicle operators in the test fleet have been grouped, for this purpose, into five categories:

- provincial and local government
- public utilities
- police
- artisans, and small business
- messenger and delivery services

Inland's experience with each of these groups is described in the following paragraphs.

EXHIBIT 31 - VEHICLE R.O.I. vs DRIVER ATTITUDE



Provincial and Local Governments

Several of the provincial government vehicles converted in Kamloops did not show good returns on the conversion investment. This appeared to be connected with:

- low utilization of the vehicles; some appeared to travel less than 1000 km/month each
- vehicles were out of town for long periods and therefore had no opportunity to fill up on natural gas
- multiple drivers, some of whom had no familiarity with natural gas
- in general, drivers were not made familiar with the advantages to the government of the use of a lower cost fuel. Driver attitudes towards natural gas did not reflect enthusiasm, and in some cases, indicated outright fear.

It should also be noted that provincial government vehicle conversions are not eligible for either provincial or federal government grant programs. This means that the out-of-pocket cost to the government is greater than for commercial users.

The one converted vehicle operated by the City of Kamloops was an exception to the general government pattern. While the driver was neutral about the fuel, the truck was operated on natural gas for a very high percentage of the time, and therefore showed a good return.

Public Utilities

All but one of the public utility vehicles in the test fleet belonged to Inland, and so it would be reasonable to expect that driver attitudes would be favourable. Most, but not all, were. The percentage of operation on natural gas was, in fact, reasonably high, but the variation in return again indicates the need to choose carefully which vehicles to convert. In all cases, the return on the kit investment was above the company's hurdle rate, but seven of the Inland vehicles travelled less than 1000 natural gas powered kilometers per month.

Inland also converted three heavy trucks. The natural gas operating percentages on these vehicles appear rather low, which may reflect the fact that they had no regular drivers and were used mainly as travelling workshops. Due to gaps in the reporting of fuel purchases, the data on these vehicles is incomplete and therefore inconclusive.

Police

Performance is most important to police drivers, and their response was generally unenthusiastic towards natural gas. However, there seems little doubt that the conversions on the two RCMP cars in the test fleet suffered from poor tuning. It is important for the success of a conversion not only that the driver be interested, but also that the mechanic responsible for the installation be enthusiastic as well. Later in the program, the kits on these vehicles were re-tuned, resulting in marked improvements in performance.

Despite a rather poor start, and without a high percentage of their time on natural gas, the vehicles involved turned in good ROI figures because of the high mileages that they were driven.

Artisans and Small Business

This group turned in some of the best natural gas ROI performances, and showed, in general, the most positive attitudes towards natural gas use. What is most significant, however, is that they personally benefitted from the savings in fuel on their vehicles.

These small businessmen and artisans owned and drove their own vehicles, used them intensively, and looked after them well. They showed a great deal of interest in all aspects of the test fleet program, and were most conscientious in recording and submitting test data.

Messenger and Delivery Services

As a group, these vehicles showed the highest ROI figures, and displayed a positive attitude towards natural gas fuelling. Their major complaint was that, with the very high distances travelled, they had to refuel on natural gas two or three times a day. Nevertheless, they used a great deal of fuel, and so made very substantial savings.

The best ROI performance in the fleet was made by a courier vehicle which was run 92% on natural gas.

Summary of Group Performance

It was noted earlier that Inland personnel spent a great deal of time contacting drivers of the test fleet to follow up for missing data, locate non-reporting vehicles, ensure that vehicles were running well, etc. It was apparent that several elements were essential to a successful conversion:

- selection of a vehicle which was doing enough mileage within reach of the fuelling station
- continuing education of the driver(s) in the purpose and operation of the natural gas conversion
- a good quality conversion, properly maintained in a good state of tune
- good fuelling service from the station
- driver motivation to take an interest in the vehicle and to save money on fuel, even at some inconvenience to himself

There is no doubt that this last element is the most important one. It can best be provided in an owner-operator situation; if a deliberate effort is made in driver education, it can also be managed in an employer-employee relationship.

VEHICLE ECONOMICS

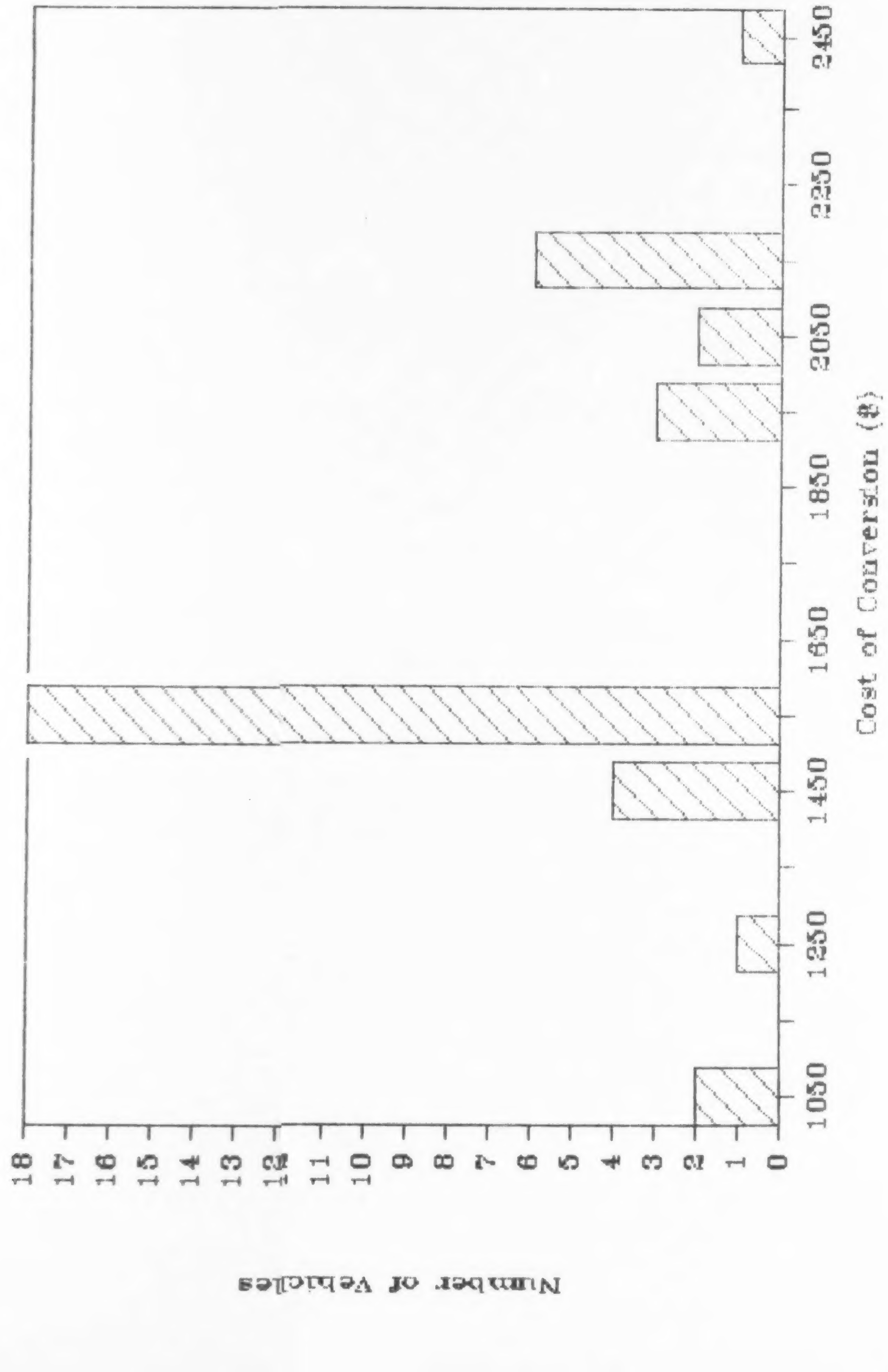
The following deals with the economics of conversion from the point of view of the vehicle owner.

Cost of Conversion

The vehicle owner is asked to pay completely for the conversion before he gets any economic benefit. He can offset against this cost any federal or provincial government grants for which he may be eligible. In reality, however, he is being asked to invest a substantial amount of money in a new and (certainly in the case of Kamloops in 1983) untried technology.

The cost of conversion, net of government grants, for the Kamloops fleet averaged $2000 per vehicle. This was comprised of a parts cost of $1550 for a two-cylinder conversion, plus labour costs of $550 - $650, less government grants. It should be noted that government entities are not eligible for grants, thus making their out-of-pocket costs greater by that amount than private owners. Exhibit 32 shows the cost of conversion for all the vehicles in the Kamloops test fleet. Since 1983, the cost of conversion is estimated to have risen some $300 for a standard first generation kit.

EXHIBIT 32 - COST OF CONVERSION DISTRIBUTION



Fuel Savings

Fuel savings for the test fleet are calculated on the basis of a saving of 24 cents for every litre equivalent of natural gas used. Inland was responsible for the pricing of natural gas at the dispenser and attempted to maintain the difference between natural gas and gasoline prices at this level, despite sometimes rapid fluctuations in gasoline prices in response to competition in the area.

This resulted in prices during the test period being set as follows:

	Price per kg.	Litre Equivalent Price
February 7 - February 14, 1983	41.2¢	23.9¢
February 15 - July 3, 1983	34.2¢	19.9¢
July 4, 1983 - January 31, 1984	37.8¢	21.9¢
February 1, 1984	41.2¢	23.9¢

The litre equivalent prices are about half those of regular gasoline at the same station.

Return on Investment

These fuel cost savings, and hence the resulting calculation of annualized return on the vehicle owner's investment in the conversion, are sensitive to the following variables:

- distance travelled; the greater the distance travelled by the vehicle, the more fuel would be used, and the greater the potential saving from natural gas use
- vehicle economy; the more litres of fuel used per 100 kilometers, the greater the potential for saving
- percentage of natural gas used; the greater this percentage, the greater the saving

Exhibit 33 shows the return on investment by vehicle, together with the distance travelled per month on natural gas, the vehicle economy on natural gas (equivalent litres per 100 kilometers) the percentage of natural gas used, and the net cost of the conversion.

EXHIBIT 33 - RETURN ON INVESTMENT BY VEHICLE

License Number	Year	Make	Model	Owner	% Time on NG	NGV L.Eq. /100k	Conv Co$t	EstNG Km/Mo	ROI %
4560LC	1982	Ford	Van	KIExpress	92	25	1600	4125	210
5297JK	1982	Ford	Van	Prestige	65	36	1600	2703	201
4559LC	1982	Ford	Pickup	KIExpress	62	25	1600	3322	162
5299JK	1982	Ford	Van	Prestige	63	30	1600	2795	154
8536KP	1983	Ford	Pickup	BCBrg	72	16	1600	3859	124
4647KV	1977	Ford	Pickup	Townsend	87	30	1600	1270	116
CHG293	1983	Chev	Sedan	RCMP	61	24	2100	1084	99
4561LC	1982	Ford	Pickup	KIExpress	83	25	1600	5237	93
6534FL	1980	Ford	Pickup	CityK	86	28	1600	1515	86
3232KB	1981	Dodge	Van	A&A Blr	67	25	1500	1613	82
CHG294	1983	Chev	Sedan	RCMP	45	24	2100	1858	75
5469GL	1980	Chev	Pickup	KMContr	90	20	1412	1441	66
5646JL	1981	Dodge	Pickup	Inland	99	19	2415	2519	59
CCW759	1980	Ford	Sedan	Inland	71	20	1300	1143	57
ACS414	1980	Chev	Sedan	Hydro	86	19	1600	1259	56
CNGNO1	1981	GMC	Pickup	Northsde	36	14	1050	1147	52
JDK472	1977	Chev	Sedan	Inland	65	22	1595	741	52
9696KF	1982	Dodge	Pickup	Inland	66	20	1600	1245	47
4347FR	1978	Ford	4X4	Towne	81	22	1050	1405	46
0075JV	1981	Dodge	Pickup	Inland	53	18	1600	1160	44
8280GF	1981	Dodge	Pickup	Inland	35	24	1600	874	42
5447JL	1981	Int'l	Truck	Inland	44	38	1995	789	40
4472GA	1980	Chev	Van	Inland	52	30	1600	729	38
BVS247	1982	Dodge	Sedan	Inland	68	12	1600	1497	37
6783FL	1981	GMC	Van	Bottling	25	29	1600	618	36
1988LD	1984	Chev	Pickup	Inland	80	24	1500	619	32
8282GF	1979	Sier.	Pickup	Inland	37	27	1600	462	25
GBX658	1980	Chev	Sedan	Inland	76	18	1600	629	23
7058JG	1982	Dodge	4X4	Government	43	23	2000	566	21
1422FB	1980	GMC	Pickup	Government	38	27	2000	383	19
EPR241	1975	Buick	Sedan	College	38	22	1500	651	15
ABF495	1980	Ford	Sedan	Government	26	14	2155	528	12
ABF811	1981	Ford	Sedan	Government	31	17	2155	298	9
ABF497	1980	Ford	Sedan	Government	17	19	2155	358	7
AAD573	1978	Plym.	Sedan	Government	40	21	2155	230	6
AAG903	1979	Ford	Sedan	Government	15	15	2155	293	6
AAD526	1978	Plym.	Sedan	Government	18	13	2155	224	5

SUMMARY

It is clear that, despite the high cost of conversion, most commercial vehicles achieved a satisfactory return on the investment, though only a few achieved near the maximum potential. However, a large part of this varied test fleet showed significant savings.

There is no doubt, however, that the initial cost of conversion is a real deterrent to many vehicle owners to fuel with natural gas. A conversion financing scheme has been initiated by B.C. Hydro in their service area, and has proved very effective in encouraging vehicle owners to install natural gas equipment; essentially, it permits the vehicle owner to pay for the conversion as he realizes fuel cost savings.

SECTION 4 - OPERATING THE TEST PROGRAM

This section of the report describes the operation of the test program, the data collection and processing, and some conclusions reached by the staff of the project.

DATA COLLECTION AND PROCESSING

The basic principles of data collection for this project were as follows:

- a basic file was set up for each vehicle in the test fleet. This file would describe the vehicle and its conversion, and give certain descriptive information
- data would be collected from each vehicle operator on fuel fills (natural gas or gasoline) as follows:
    - date
    - kilometers
    - reading of natural gas hour clock
    - reading of gasoline hour clock (note that both clocks wired to fuel selector switch on each converted vehicle)
    - quantity of natural gas purchased (kg.)
    - quantity of gasoline purchased (litres)

  These readings were turned in on a "Performance Test Log" card, which had space for 10 readings. (An example of one of these cards is shown as Exhibit 34.) As an incentive to turn in these cards, drivers were given a Western Express ticket for each completed one. (No drivers, to our knowledge, actually won any prizes.)
- data was collected on daily ambient temperatures by an existing Inland system.

The data was then keypunched and input into Inland's mainframe computer system, as illustrated in Exhibit 35.

The following calculations were then made:

- a check of data integrity to ensure that each vehicle was recording data continuously, without unexplained gaps and out-of-sequence time or odometer recodings
- number of months since conversion
- kilometers from conversion to last available data
- % of time on natural gas, taken from clock readings

EXHIBIT 34 - PERFORMANCE TEST LOG

PERFORMANCE TEST LOG

VEHICLE LICENSE No. 4472GA

DAY	MONTH	YEAR	ODOMETER READING	CLOCK HOURS GASOLINE	CLOCK HOURS CNG	FUEL PURCHASED GASO (L)	FUEL PURCHASED CNG (kg)	ROADS DRIVEN (✓) CITY	ROADS DRIVEN (✓) HWY.	ROADS DRIVEN (✓) UNPAVED	LOAD (✓) YES	LOAD (✓) NO	PERF. (✓) ACCEPT	PERF. (✓) UNACCEP	DRIVER'S INITIALS
19	01	84	66729.	16.9	211.2	.	14.2	✓				✓	✓		
20	01	84	66708.	16.9	214.	.	14.9	✓				✓	✓		
26	01	84	66868.	16.9	217.	.	18.5	✓				✓	✓		
02	02	84	66968.	17.5	221.	.	18.7	✓				✓	✓		
07	02	84	67037.	17.7	223.2	.	15.2	✓				✓	✓		
08	02	84	67131.	17.7	226.1	.	17.2	✓				✓		X	
10	02	84	67189.	17.7	228.	.	[illegible]	✓				✓		X	
15	02	84	67282.	17.2	233.	.	14.2	✓				✓	✓		
16	02	84	67345.	17.7	236.4	.	12.4	✓				✓	✓		
17	02	84	67695.	19.5	239.8	.	19.6		✓			✓	✓		

DRIVER'S COMMENTS ON BACK ☐

ING 216

EXHIBIT 35 - COMPUTER INPUT

```
******  NGV*LCGS  ******

1190.       1988LD 030484 0022560 00396 00025 17764 000 1     1 1
1200.       1988LD 050484 0023780 00437 00025 17676 000 11    1 1
1210.       1988LD 120484 0024840 00467 00026 17078 000 11    1 1
1220.       1988LD 170484 0026039 00503 00026 15486 000 1     1 1
1230.       1988LD 260484 0028317 00542 00044 18671 000 11    1 1
1240.       1988LD 010584 0030850 00587 00071 19136 553 11    1 1
1250.       1988LD 070584 0032920 00630 00081 23086 472 11    1 1
1260.       1988LD 100584 0034110 00660 00083 16858 000 1     1 1
1270.       1988LD 180584 0035061 00688 00083 12498 000 11    1 1
1280.       1989LD 040284 0028722 00000 00028 00000 634  1    0 1
1290.       1989LD 070284 0031721 00000 00075 03000 700 1     0 1
1300.       1989LD 120284 0032996 00000 00120 03000 622 1     0 1
1310.       1989LD 150284 0036205 00000 00212 00000 663 1     0 1
1320.       1989LD 170284 0037745 00000 00261 00000 621  1
1330.       1989LD 230284 0042104 00000 00330 03000 703  1    1 1
1340.       1989LD 240284 0044605 00000 00395 03000 664  1    0 1
1350.       1989LD 260284 0047366 00000 00432 00000 661  1    1 1
1360.       1989LD 030384 0049840 00000 00497 00000 683  1    1 1
1370.       1989LD 080384 0051854 00000 00567 00000 697 1     0 1
1380.       1989LD 090384 0055196 00000 00614 03000 592  1    0
1390.       1989LD 100384 0056905 00000 00654 03000 585  1    0 1
1400.       1989LD 210384 0058506 00000 00691 03000 656 1     1
1410.       1989LD 230384 0059848 00000 00749 00000 615 1     1 1
1420.       1989LD 260384 0065134 00000 00819 00000 394 1     0 1
1430.       1989LD 290384 0067372 00000 00855 03000 660  1    1 1
1440.       3232KB 111183 0467980 00016 00000 15400 000  1    1 1
1450.       3232KB 141183 0469380 00062 00000 17200 000 11    1 1
1460.       3232KB 161183 0471510 00090 00012 17800 000  1    1 1
1470.       3232KB 181183 0472760 00130 00012 17300 000 1     1 1
1480.       3232KB 231183 0474300 00175 00020 18300 000 1     1 1
1490.       3232KB 261183 0476210 00191 00033 186001163 1     1 1
1500.       3232KB 291183 0477460 00254 00033 15400 000 1     1 1
1510.       3232KB 291183 0479030 00277 00033 16300 000  1    1 1
1520.       3232KB 011283 0480240 00321 00033 17200 000 1     1 1
1530.       3232KB 031283 0481370 00365 00033 19300 000 1     1 1
1540.       3232KB 051283 0482360 00399 00033 15950 000 1     1 1
1550.       3232KB 061283 0484160 00430 00033 16600 000  1    1 1
1560.       3232KB 081283 0485230 00471 00033 17600 000 1     1 1
1570.       3232KB 091283 0485730 00487 00033 07700 000 1     1 1
1580.       3232KB 131283 0494410 00487 00164 000001100  1    0 1
1590.       3232KB 141283 0498090 00515 00193 17300 000 11    0 0
1600.       3232KB 161283 0500270 00548 00206 19100 000  1    1 1
1610.       3232KB 201283 0503700 00581 00294 030001190 1     1 1
1620.       3232KB 231283 0504390 00581 00386 12400 000 1     1 1
1630.       3232KB 301283 0504700 00582 00400 10000 000 1     1 1
1640.       3232KB 301283 0508930 00582 00603 000001146 1     1
1650.       3232KB 040184 0510100 00602 00649 08600 000 1     1 1
1660.       3232KB 040184 0511880 00631 00649 17700 000  1    1 1
1670.       3232KB 070184 0513070 00673 00649 17800 000 1     1 1
1680.       3232KB 100184 0514010 00710 00649 14400 000 1     1 1
1690.       3232KB 120184 0516500 00744 00672 18500 000 11    1 1
1700.       3232KB 140184 0517330 00791 00675 14500 000 1     1 1
1710.       3232KB 170184 0518430 00832 00675 13100 000 11    1 1
1720.       3232KB 200184 0521320 00855 00735 19300 000 1     1 1
1730.       3232KB 200184 0522870 00875 00735 16300 000  1    1 1
1740.       3232KB 230184 0524170 00926 00735 20300 000 1     1 1
1750.       3232KB 250184 0526120 00951 00752 16000 000  1    1 1
1760.       3232KB 260184 0527870 00971 00775 12500 000  1    1 1
1770.       3232KB 260184 0529650 00996 00775 17300 000  1    1 1
1780.       3232KB 280184 0530680 01030 00775 000001113  1    1 1
```

- fuel economy on gasoline (litres/100km.), calculated during an uninterrupted interval of fuelling, with no missing information, with gasoline kilometers allocated according to the proportion of the total clock time spent on gasoline
- fuel economy on gasoline, converted to miles per gallon
- fuel economy on natural gas (kg/100km.), calculated in a similar fashion to gasoline
- fuel economy on natural gas, converted to litre equivalents per 100 km. at a ratio of 1.72 equivalent litres per kilogram
- fuel economy on natural gas, converted from litre equivalents per 100 km. to miles per equivalent gallon
- average vehicle range between natural gas refuellings, excluding intervals when gasoline is used
- average time (days) between natural gas refuellings
- dollar savings contribution, calculated on total distance travelled since conversion x percentage on natural gas x litre equivalents per 100 km. x $.25 per litre equivalent.
- total cost of conversion
- annual return on investment, calculated on the basis of savings contribution per month since conversion, x 12, divided by the cost of conversion

Fleet averages were then calculated for:

- km. traveled per vehicle since conversion
- percentage of time on natural gas
- fuel economy on gasoline, in terms of litres per 100 km.
- fuel economy on natural gas, in terms of equivalent litres per 100 km.
- average range (km.) between natural gas refuellings
- average time (days) between natural gas refuellings

The results for each vehicle were periodically

EXHIBIT 36 - FORM LETTER TO VEHICLE OWNER

INLAND NATURAL GAS CO. LTD.
BOX 12503, 1066 WEST HASTINGS STREET,
VANCOUVER, BRITISH COLUMBIA V6E 3G3
TELEPHONE(604) 684-0484

June 11, 1984

MR J MORAN
MINISTRY OF FORESTS
1280 SUMMIT DRIVE
KAMLOOPS B C
V2C 1T8

Re: Natural Gas Vehicle Fuel Performance Test
1980 3/4 TON PICKUP TRUCK
License No. 14 22-FB

Report No. 1

Attached is a copy of the data header and set of photographs which we have on file for the above noted converted vehicle. Please take a moment to review the content and advise Phil Murray or Ken Andrews through our Kamloops office (374-8121) of any discrepancies.

The primary source of ongoing information for input into our analysis is the "Performance Test Log" prepared by the driver of each vehicle. Based on the logs we've received to date from your drivers, the following preliminary results are worth noting:

Months since vehicle conversion	16
Kilometres since conversion until last available data	13448
Percentage of operating time on natural gas	68
Fuel economy on gasoline	32 l / 100 km
or	9 miles / gallon
Fuel economy on natural gas	16 kg / 100 km
or	28 l equiv. / 100 km
or	10 miles / equiv. gallon
Average range between natural gas refuelings	147 km.
Average time interval between refuelings	10.2 days

Based on an average natural gas cost to date (22 cents / litre equivalent) and an average gasoline cost to date (47 cents / litre equivalent), the fuel cost savings have contributed $ 563 toward the $2000 cost of conversion, less grants. The effective return on investment, on an annual basis, is therefore 21%.

Wholly-Owned Subsidiary Companies
COLUMBIA NATURAL GAS LIMITED • ST. JOHN GAS & OIL CO. LTD. • INLAND DEVELOPMENT CO. LTD.

EXHIBIT 36 - FORM LETTER, PAGE 2

As we noted to you when the program was initiated last year, the results of your particular vehicle's performance test will not be communicated to any other participant. However, for comparison, the fleet average (44 converted vehicles) results to date are as follows:

Fleet average kilometres travelled since conversion	21187
Fleet average percentage of time on natural gas	63
Fleet average fuel economy on gasoline	22 l / 100 km
Fleet average fuel economy on natural gas	22 l equiv / 100 km
Fleet average range between natural gas refuelings	165 km
Fleet average time interval between refuelings	5.0 days

We have recently completed initial oil sampling and driver questionnaires, the results of which will be communicated to you when they are available.

Yours truly,

B. F. Vernon
Assistant to Vice President,
Engineering

communicated to the vehicle owner, using a form letter (Exhibit 36).

Data Accuracy

As noted in more detail in the section of this report dealing with the vehicles, considerable difficulty was experienced in maintaining the discipline necessary to gather accurate, consistent, and continuous data over a time span of two years or more. Three converted and one control vehicle were lost to the program through relocation or accident. A number of others spent much of their time out of town, and data collection (and natural gas use) was severely interrupted.

Other vehicles were driven by a variety of different drivers, some of whom were ignorant of natural gas fuelling or equipment. Finally, the varied nature of the fleet, and the scattered locations of owners and operators, often made it difficult to insist on or follow up for missing information.

Detailed service data, on such a varied fleet, proved impossible to collect; it appears that this would only be meaningful under highly disciplined fleet management at one central location. Information originally sought on road conditions, loads, and type of driving proved so susceptible to varied interpretation as to yield no significant results.

However, throughout the two year test period, about 60% of the test vehicle operators faithfully reported distance run, hours clocked, and fuel purchased, and it is their efforts that are responsible for the usefulness of the data in this report. The majority of the tables in this document list only those vehicles that reliably reported data. We are most grateful to those operators for their consistent efforts.

EQUIVALENCE

Throughout the introductory period in Kamloops, and in all the calculations in this report, one kilogram of natural gas is assumed equivalent to 1.72 litres of gasoline. Inland originally set out this equivalence in a letter to Consumer and Corporate Affairs (Exhibit 37).

It is obviously extremely important, from a marketing point of view, to present to the customer a price per unit that he can compare with the current posted price of gasoline. It is also recognized that in practice, no single factor can be applied to all vehicles, since some vehicles

EXHIBIT 37 - LETTER TO CONSUMER & CORPORATE AFFAIRS

INLAND NATURAL GAS CO. LTD.
BOX 12503, 1066 WEST HASTINGS STREET,
VANCOUVER, BRITISH COLUMBIA V6E 3G3
TELEPHONE(604) 684-0484

January 17, 1983

Mr. Jim Taggart, Regional Manager,
Consumer and Corporate Affairs Canada,
Electricity and Gas Inspection,
3625 Lougheed Highway,
Vancouver, B.C.
V5M 2A6

Dear Mr. Taggart:

This will confirm and expand upon certain aspects of our telephone conversation January 13, 1983 regarding natural gas vehicle fuel pricing at our Kamloops dispensing facility.

We have purchased a dispensing unit from CNG Fuel Systems Ltd. which, as you know, features a Micro-Motion mass flow meter. The unit displays the mass in kilograms and the price per kilogram is indicated electronically on each dispensing head. My understanding is that you will be arranging for the verification of our meters in Kamloops sometime during the next two to three weeks.

Although the fuel will be sold in mass units it is our intention to display at the facility what is, by our calculation, the equivalent price in terms of litres of unleaded gasoline. We would expect the higher heating value of unleaded gasoline to be 34.8 MJ/litre (150,000 Btu/I.Gal) and the higher heating value of natural gas to be 54.2 MJ/kg. (1050 Btu/ft^3 and a relative density to air of 0.59). On a straight energy conversion basis, therefore, 0.64 kg of natural gas would be equivalent to a litre of gasoline. However, based on the experience of B.C. Hydro, B.C. Research and CNG Fuel Systems Ltd., a motorist might reasonably expect a 10% net increase in fuel efficiency while utilizing natural gas. This suggests the relationship that 0.58 kg of natural gas would be equivalent to approximately a litre of gasoline from the engine's perspective. The facility, therefore, could have a posted natural gas price of, say, 41¢/kg and a posted equivalent price of 24¢/litre.

We recognize that the development of natural gas as a vehicle fuel is very much in its formative stage in B.C. at this time.

cont....2/

EXHIBIT 37 - LETTER TO CONSUMER & CORPORATE AFFAIRS, PAGE 2

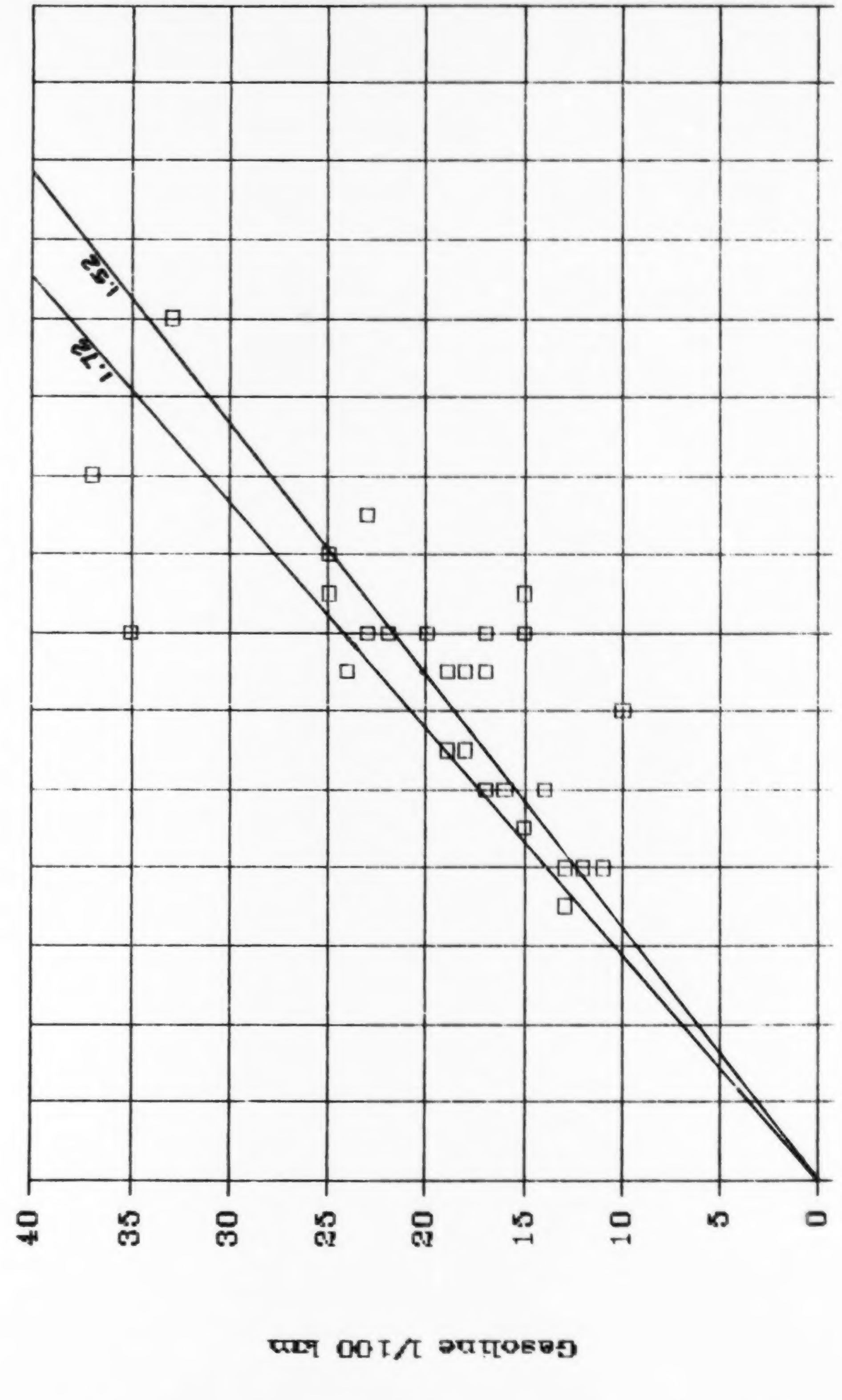
As other methods of measuring natural gas become available, and as additional vehicle performance data is forthcoming we would expect the units of sale and the equivalent to other fuels to evolve. At the outset, though, it is the foregoing system that we would prefer to adapt. Please direct any comments or suggestions you might have regarding this approach to my attention.

Yours truly,

Bruce F. Vernon,
Assistant to Vice-President,
Engineering

BFV/nb

EXHIBIT 38 - EQUIVALENCE OF NATURAL GAS TO GASOLINE



are more efficient than others on natural gas, as compared to gasoline.

These vehicle-to-vehicle differences depend not only on basic engine design, vehicle operating conditions and loads, and the driving habits of their owners, but also on the conversions themselves, and whether tuning of the engine has been carried out for maximum efficiency on natural gas or gasoline, or some combination or compromise.

We have reviewed the actual experience of the Kamloops fleet in this regard; some vehicles recorded the same litres/100km. on natural gas as on gasoline, indicating that for them, the assumed equivalence factor was correct. Others exhibited wide differences. Exhibit 38 shows the equivalence as demonstrated by those fleet vehicles recording sufficient reliable data to make comparison possible.

This graph shows that while some vehicles fell right on the 1.72 litres/kg. line, a number fell below it. An equivalence factor of 1.52, which would result from a comparison of the Lower Heating Values of the two fuels, has also been drawn on the graph.

We conclude that, given vehicle-to-vehicle differences, the results from these figures cannot be used to prove or disprove the assumed equivalence figure.

THE INLAND TEAM

The Kamloops Demonstration Project was carried out by the following Inland Natural Gas Co. Ltd. personnel:

Mr. B. F. Vernon, Vancouver (Project Manager)

Mr. R. B. Anastasiou, Vancouver
Mr. R. H. Nadeau, Kamloops
Mr. P. J. Murray, Kamloops
Mr. G. W. Gregson, Kamloops
Mr. F. Dwyer, Kamloops
Mr. B. Major, Kamloops

We would also like to acknowledge the assistance of:

Dr. D. A. J. Millar, Davis Engineering, Burnaby
Mr. P. S. E. Brown, Patrick Brown Systems, Vancouver

Inland especially appreciates the contribution to this study of the vehicle owners and operators who participated.

APPENDIX A

VEHICLE CONVERSION KIT MODIFICATIONS

APPENDIX A

VEHICLE CONVERSION KIT MODIFICATIONS

This Appendix identifies component and system failures experienced during the test program. It covers Garretson, Renzo Landi, and Tartarini components. The comments were prepared by Inland service staff.

The only difference between these three systems are regulators and mixers. Tanks, lines, fill valves, shut-offs, etc. are common to all three systems. Of the 41 converted vehicles that remain in the program in the fall of 1985, 38 are Garretson equipped, 3 are Renzo Landi, and 3 are Tartarini.

GARRETSON SYSTEM

Tru-Lite Regulator (1st Stage)

Rubber seat material, incompatible with high pressure gas operation, frequently caused overpressurization of the first stage regulator, and would consequently activate the mangement block. Over a period of time, first and second stage rubber seat material, being much too porous, would absorb high pressure gas. When supply pressures lowered, absorbed gas in seat could not release quickly enough, resulting in separation of rubber material.

Seat material is now made of Delrin (nylon), eliminating absorption and separation problems.

Leakage from base threads of regulator occurs if main rubber diaphragm is installed incorrectly, or poorly manufactured diaphragms are installed. If inadequately assembled, the diaphragm assembly tends to work itself loose to the point when complete detachment occurs causing erratic pressures and regulator operation.

Garretson has designed a metal diaphragm to fit the Tru-Lite, but use has been limited because of many small problems encountered. Following proper procedures on installation of the rubber diaphragms can ensure good operation.

KV Regulator

2nd stage inlet needle valve

The original inlet needle valve, with rubber seat attached to needle using adhesive, would eventually separate, blocking inlet gas flow.

The redesigned needle valve has a recess in the needle allowing rubber to mold inside, eliminating further separation.

Management Block

Many of the original valves were installed in reverse, sealing outlet gas flow. The valve designed to seal the inlet gas caused dismemberment of the O-ring seal and leakage of gas on activation. All valves have now been modified.

There were some instances of leaks in the burst disc assemblies, and the assemblies had to be replaced.

High Pressure Solenoid

If fittings were installed too tightly, the aluminum base of the solenoid cracked and leaked gas. Dirt and metal filings also cause leak-by and sticky solenoid plungers.

Solenoid Control Box

The purpose of this box is to control auto/manual priming and high pressure solenoid operation. This control box is still unreliable and trouble shooting of intermittent faults is difficult.

Four generations of control boxes have been used, each one updated from the last. The first three were protected to .5 amp and were difficult to work with. The latest model, protected to 1.5 amps is more robust, but still not troublefree.

Garretson Mixers

Garretson utilizes the vacu-lift design for their mixers; there are three models:

- model 214 - 8 cyl. engines
- model 213 - 6 cyl. engines
- model 212 - 4 cyl. engines

These mixers have adjustable diaphragms, a power screw, and a vacuum idle solenoid.

The optional power valve is designed to give leaner cruise mixtures and richer mixtures under extreme load conditions. Colder weather affects the Teflon seals on the original valve, and the natural gas drawn past gave an over-rich idle. An improved second generation valve is now in use.

RENZO LANDI SYSTEM

Unlike the Garretson system, the Renzo Landi is a very compact unit which incorporates a 1st, 2nd, and 3rd stage regulator into one housing. The high pressure solenoid, operating against tank pressures, and the fuel gauge sending unit are both included in the unit.

Two models are used in Kamloops: the TN2-C for general applications, and the TN2-CS for larger applications with heavy fuel demands.

Idle Spring and 3rd Stage Diaphragm

The regulator controls idle mixtures by the 3rd stage diaphragm using an idle control spring. The tension of the spring and the stiffness of the diaphragm both vary with changes in temperature. Thus idle settings constantly change and resetting becomes necessary.

Switching

The Renzo NG/gasoline switch is often unreliable; it is a sealed unit and cannot be repaired. It must be replaced if it gives trouble.

Start/Idle Valve

The amount of priming is proportional to the idle setting. CNG Fuel Systems have developed a vacuum controlled start/idle valve, which controls the idle spring tension on start and idle, and supplies the engine with a richer priming mixture.

Inlet Needle and Seat

Regulator squealing under load has been traced to:

1. When heavy gas flow is combined with an overheated regulator, the first stage high pressure spring would hum violently. To correct this, place a 3/4" piece of heavy wall surgical tubing inside the spring.
2. As high pressure gas enters through the fuel inlet, it makes two sharp turns past the inlet valve seat. Under heavy gas flow, turbulence causes squealing. Remachining the needle and seat corrects the problem.

Renzo Landi Gas Mixers

The V.R.I. gas mixer supplied by C.N.G. Fuel Systems works on the fixed venturi principle, and is installed inside the stock air cleaner. For smaller displacement egines the fixed V.R.I. mixer is used; for larger displacements the vacu-lift mixer reduces potential horsepower loss on gasoline.

These mixers are sometimes difficult and time-consuming to install because of required remodeling of the original air cleaner.

TARTARINI SYSTEM

Tartarini Regulator

These regulators have not been used extensively in Kamloops. The regulator is similar to the Renzo Landi design, with the addition of a priming solenoid. This is not adjustable and delivers gas to the mixer at 35 psi, causing frequent flooding.

For larger engines, internal modifications must be made to the regulator.

Tartarini Gas Mixer

This is similar in design to the Garretson or V.R.I. mixers. The original mixers were sized for each engine, and were not adjustable. Later models have been made oversized, and a power screw incorporated.

MISCELLANEOUS NGV COMPONENTS

Master Shut-off Valves

The Parker 1/4 turn shut-off valve often leaks past the Teflon seals at the stem and side nuts. These valves have been replaced by a New Zealand made shut-off and fill valve combination. This has worked well, but six or more turns are required for complete shut-off.

Both types of fill valves have displayed heavy vibration and occasional freeze-off of check valves at the end of fill.

APPENDIX B

VEHICLE INCIDENT REPORTS

INLAND NATURAL GAS CO. LTD.

Incident Report February 4, 1985

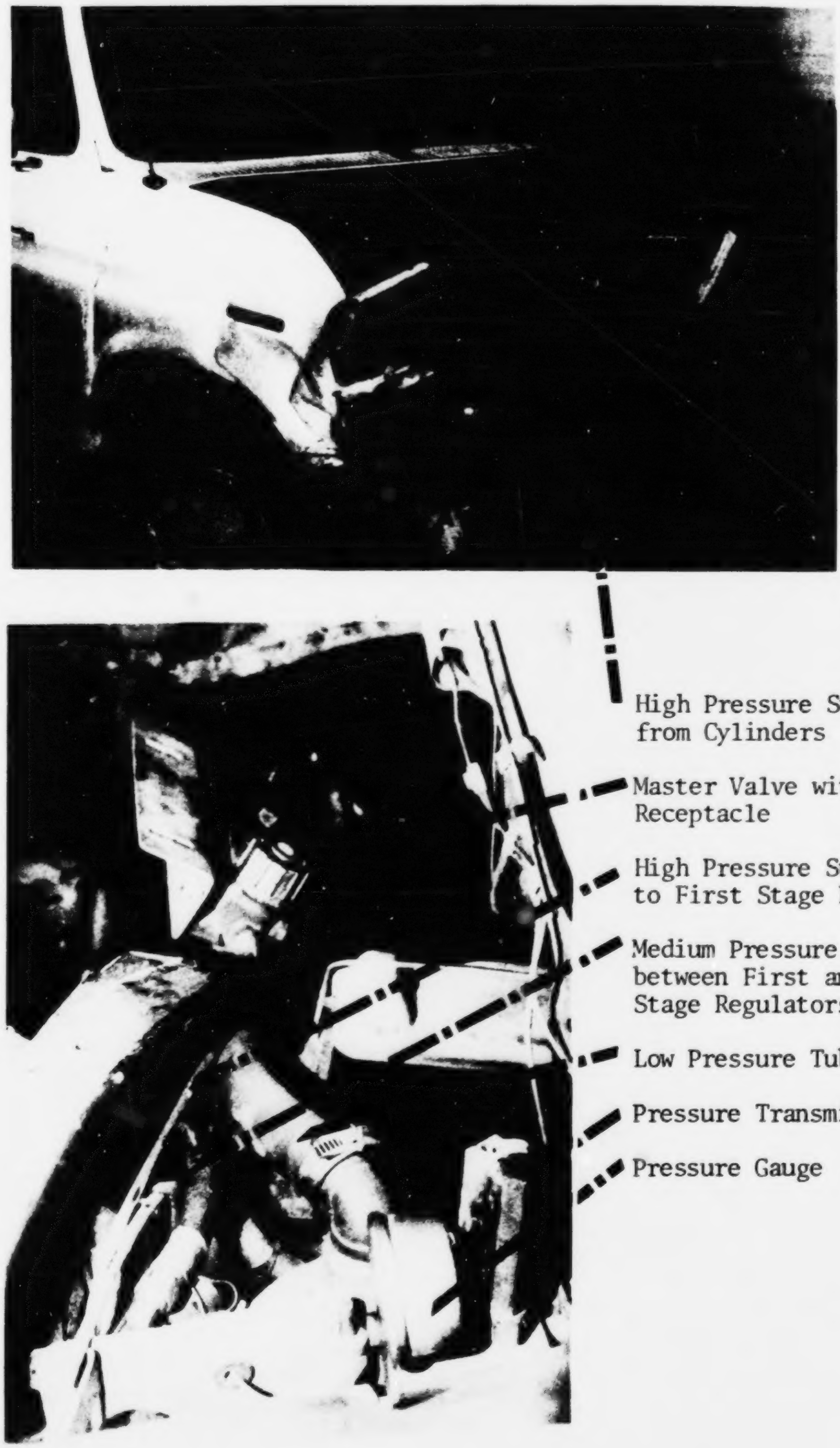
Kamloops Industrial Express Lic. 45 60 LC
(formerly 01 49 JF)

1982 Ford Econoline Van

For original description and photographs of conversion equipment arrangement see pages 43-45 of Vehicle Descriptions volume (note that the vehicle was repainted from blue to white since the program started).

On November 6, 1984 the above noted unit was involved in a head-on collision with another vehicle. No leaking of gas was reported and all underhood NGV components, although dislocated, were undamaged and operable. No dislodging or movement of the NGV storage cylinders installed in the rear cargo space was observed. The owner advises that the conversion components will be removed and reinstalled on the next unit purchased.

INLAND NATURAL GAS INCIDENT REPORT
KAMLOOPS INDUSTRIAL EXPRESS
LICENCE 45 60 LC


High Pressure Supply Tubing from Cylinders
Master Valve with Fill Receptacle
High Pressure Supply Tubing to First Stage Regulator
Medium Pressure Supply Tubing between First and Second Stage Regulators
Low Pressure Tubing to Carburetor
Pressure Transmitter
Pressure Gauge

INLAND NATURAL GAS CO. LTD.

Incident Report February 4, 1985

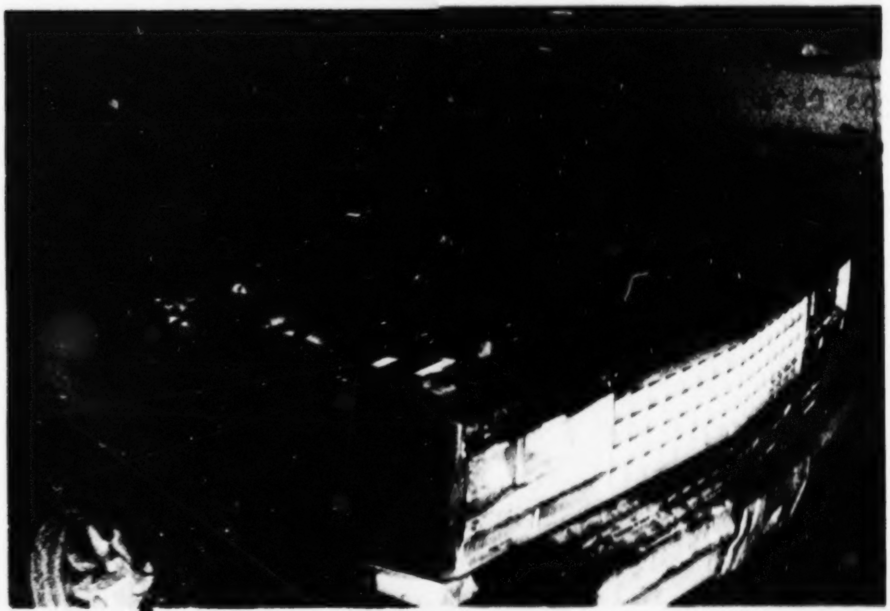
Kamloops Detachment, RCMP Lic. CHG 293

1983 Chevrolet Malibu, Unit 10B10

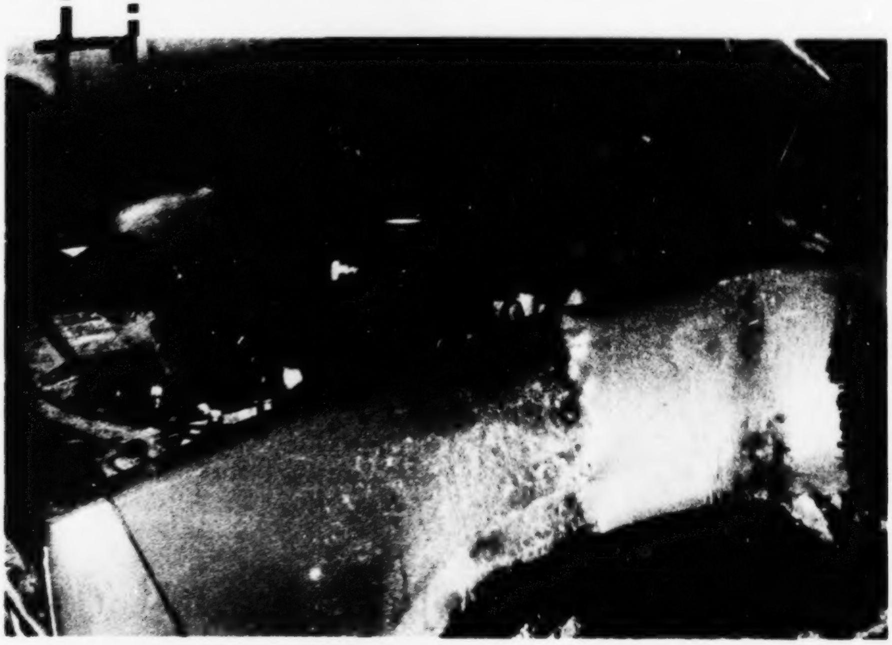
For original description and photographs of conversion equipment arrangement see pages 61-63 of Vehicle Descriptions volume.

On January 5, 1985 the above noted unit was involved in a single vehicle accident. The vehicle rolled on its side then came to rest on its roof. No leaking of gas was reported and all NGV components were intact with the exception of the air/fuel mixer which was damaged beyond repair as the vehicle's hood was pushed downward. The conversion components except for the mixer will be removed and re-installed on the replacement unit.

INLAND NATURAL GAS INCIDENT REPORT
KAMLOOPS DETACHMENT RCMP
LICENCE CHG 293

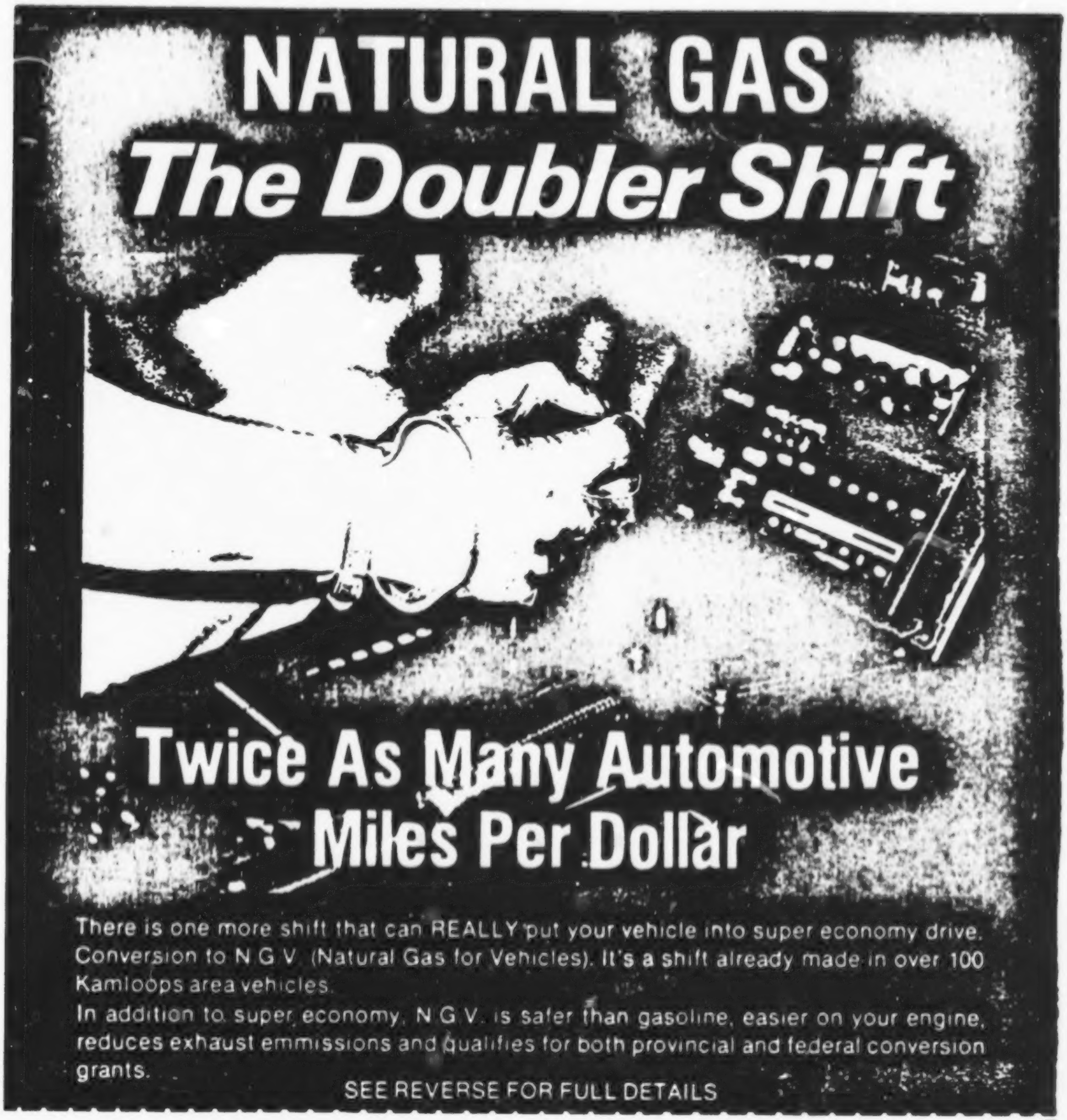


Garretson Vaccu-Lift Mixer (compressed during accident)
Low Pressure Tubing to Carburetor
Garretson Regulator Assembly



APPENDIX C

PROMOTIONAL MATERIAL


NATURAL GAS
The Doubler Shift
Twice As Many Automotive
Miles Per Dollar

There is one more shift that can REALLY put your vehicle into super economy drive. Conversion to N.G.V. (Natural Gas for Vehicles). It's a shift already made in over 100 Kamloops area vehicles.

In addition to super economy, N.G.V. is safer than gasoline, easier on your engine, reduces exhaust emmissions and qualifies for both provincial and federal conversion grants.

SEE REVERSE FOR FULL DETAILS

Please fill in details on reverse,
detach, place in envelope
and return to:

N.G.V. Information Kit
910 West Columbia Street,
Kamloops, B.C.
V2C 1L3

Most Important Automotive News in Kamloops History

Natural Gas 23.9¢ per litre (gasoline equivalent) at Kamloops Sahali Mohawk Station.

Twelve months ago Inland opened a public refueling facility at the Sahali Mohawk Service Station.

Since then, over 100 vehicles from police cars to school buses and many private vehicles have switched to N.G.V. The price of N.G.V. is less than half that of gasoline. The price spread between gasoline and natural gas is expected to continue.

NGV is World Wide

Hundreds of thousands of vehicles in Europe, New Zealand, and North America are operating on clean, efficient, natural gas. In Canada refueling outlets are opening across the country and dozens more are on the drawing board.

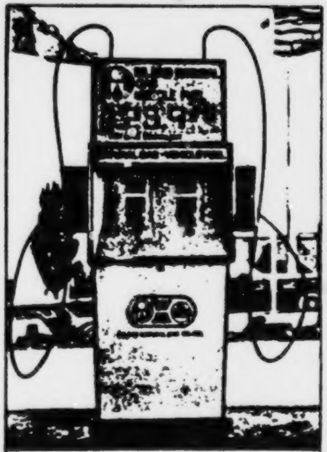
You keep your gasoline option with NGV conversion

Your NGV conversion is installed in addition to your present fuel system so you can switch back to gasoline whenever you want, even in the middle of traffic. When you trade in you can re-install your conversion unit in your next vehicle.

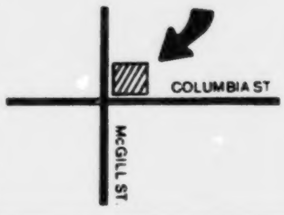
NGV is safer than gasoline

The complete storage system is under pressure and sealed at all times. The NGV tanks are extremely rugged. NGV has enjoyed an enviable world wide safety record.

Government grants of up to $700 are available to assist in conversion.



Natural Gas is now available at the Sahali Mohawk service station:



RETURN THE COUPON BELOW AND WE WILL SEND YOU AN INFORMATION KIT WITH FULL DETAILS ON NGV CONVERSION TOGETHER WITH AN ESTIMATE ON EXPECTED SAVINGS, CONVERSION COSTS AND INVESTMENT PAYBACK

Name ______________________________ Phone No. ______________

Address ____________________ City ______________ Postal Code ________

VEHICLE INFORMATION

Make ______________ Model ______________ Year ______________

Engine: No. of Cylinders _____ 4 _____ 6 _____ 8

Approximate distance travelled per year ______________ km _____ miles _____

Types of Use: Business _____ Commuting _____ Pleasure _____

NATURAL GAS VEHICLE FUEL

KAMLOOPS PERFORMANCE EVALUATION 1983/84

Application

Company/Organization: HERITAGE PLUMBING & HEATING LTD.
Address: BOX 3043
City: KAMLOOPS Postal Code: V2C 6B7
Contact Name: A. ALCOCK Title: SECRETARY
Telephone: 372-1089

Bill Alcock

- Vehicle Candidates (attach separate list if necessary):

	Make	Model	Year	Now converted to natural gas? (Circle response)	
1.	FORD 3/4 TON	F250	1977	[✓ Yes]	No
2.				Yes	No
3.				Yes	No
4.				Yes	No
5.				Yes	No
6.				Yes	No

- Control Vehicle Candidates (to be evaluated but not converted to natural gas) similar to one or more of those vehicles listed above:

1. ____________
2. ____________

- Please indicate if you would agree to the following:

	(Circle response)	
Chassis Dynomometer and Emissions Tests	[✓ Yes]	No
Oil Analysis	[✓ Yes]	No
Publication of test data without prior approval	[✓ Yes]	No

- Comments/Suggestions:

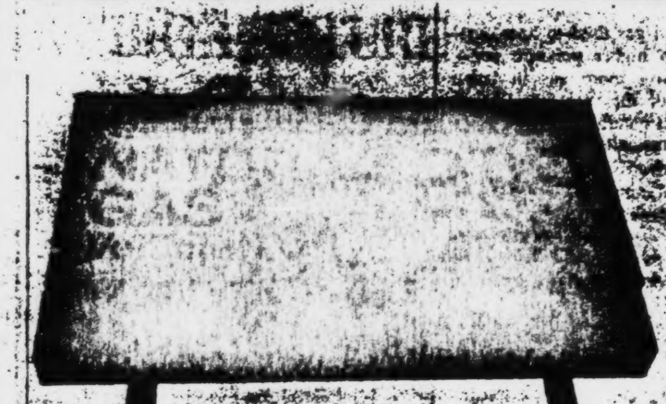
Please complete this
form and mail to:
Inland Natural Gas Co. Ltd.
Box 12503, 1066 W. Hastings St.
Vancouver, B. C. V6E 3G3
Attn: Mr. B.F. Vernon

A. Alcock July 12/83
(Signed) (Date)

A. ALCOCK
(Name - Please Print)

INLAND NATURAL GAS CO. LTD. • 1066 WEST HASTINGS ST., VANCOUVER, B.C. V6E 3G3 • [illegible]
INLAND NATURAL GAS CO. LTD. • 910 WEST COLUMBIA ST., KAMLOOPS, B.C. V2C 1L3 • (604) 374-8121

NATURAL GAS VEHICLE FUEL CATCHES ON IN KAMLOOPS



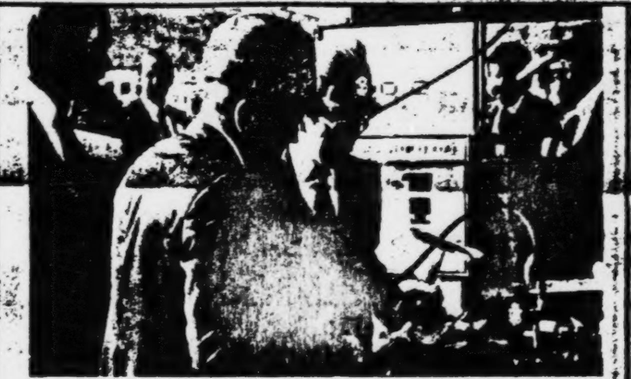
23.9¢ per litre versus [illegible] for unleaded gas.

Inland Natural Gas Co. Ltd. is pleased to announce the first anniversary of its Natural Gas for Vehicles (NGV) dispensing facility at the Sahali Mohawk Station, Kamloops, B.C. Compressed natural gas for vehicles has been available since February 17, 1983 and NGV is now firmly established as an alternative motor fuel.

In the time since the station was officially opened by Kamloops Mayor [redacted] government agencies, and private individuals have made the decision to convert their vehicles to natural gas. Sales volumes at the station have increased dramatically over that time, so much so that the station is a successful business venture in only a short twelve months.

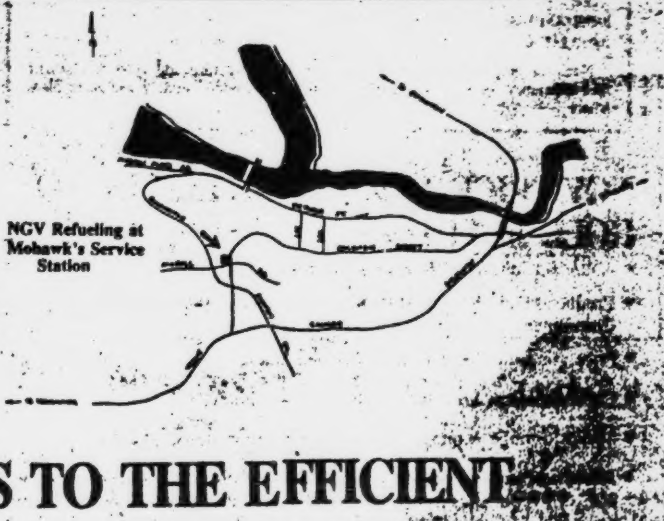
Other NGV stations are opening in British Columbia and across Canada. The most recent opening of NGV dispensing facilities took place in Prince George, B.C. where 60 taxi cabs owned by Prince George Taxi are being converted to NGV and can fill-up at their own site which is open to the public as well.

Operators are enjoying substantial savings in operating costs as NGV is approximately one half the cost of gasoline. Most conversion customers in the Kamloops area will pay back their investment in one year but some in as little as four months. As well, consumers of NGV enjoy the security of an abundant supply of natural gas produced right here in British Columbia. NGV is delivered through the same efficient and reliable pipeline system that brings natural gas to your home or business. Natural gas prices are not subject to the whims of foreign governments which make oil prices and supply so volatile.



Kamloops Mayor Mike Latta and Inland President Bob Kadlec officially open the station, February 17, 1983.

INLAND NATURAL GAS CO. LTD. WOULD LIKE TO TAKE THIS OPPORTUNITY TO THANK THE MANY PEOPLE IN KAMLOOPS WHO HAVE SUPPORTED THE NGV PROGRAM AND CONTRIBUTED TO ITS SUCCESS.



THE FUTURE BELONGS TO THE EFFICIENT...

INLAND NATURAL GAS VEHICLE FUEL
23.9
PER LITRE EQUIVALENT
NATURAL GAS - VEHICL

Mohawk staff fill you.

CALL IT NGV

(Natural Gas For Vehicles)

NGV is the same natural gas used to heat our homes. Compression to higher pressure permits the vehicle to carry more gas in less space. In many parts of the world NGV is called CNG (compressed natural gas). NGV is sold by weight; kilograms, although for comparison purposes we advertise in litres equivalent. One kg of NGV equals approximately 1,7 litres equivalent of gasoline.

REFUELING WITH NGV

Filling with NGV is very much like filling with gasoline. Drivers can self-serve, or the Sahali Mohawk staff will assist. Filling takes only three to five minutes, which is slightly longer than gasoline fill-ups. A distinctive aspect of NGV refueling is that the fill hose is usually connected to the vehicle under the hood. This conveniently allows for servicing while filling.

GAS
VEHICLE FUEL
23.9

Or serve yourself.

COMPARING VEHICLE FUELS

	NGV	PROPANE	GASOLINE
[illegible]	23.9¢	34¢*	49.2¢
[illegible]	Abundant	Limited	Imported
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Never	[illegible]	[illegible]
[illegible]	Never	Yes	Yes
[illegible]	[illegible]	Good	[illegible]
[illegible]	[illegible]	[illegible]	Adequate
[illegible]	No	No	Yes
[illegible]	Negligible	Minimal	Adverse
IGNITION TEMP.	680°c	465°c	280°c
[illegible] TEMP.	-160°c	-40°c	48-176°c
[illegible] TEMP.	Coolest	Cooler	Hottest
[illegible]	Plugs and oil stay cleaner		Fouls engine
[illegible]	Equal	20% less	Standard
RANGE	One half	About equal	Standard
[illegible] FUEL	Greater	(Seldom done)	N/A
POWER RATING	Small loss	Slight loss	Standard

* Note for propane pricing. To pump price of 29¢ litre add 20% for loss of [illegible] efficiency as substantiated by Ontario government studies and tests else-[illegible]

NGV PRICE ADVANTAGE LIKELY TO HOLD IN FUTURE

- Abundant long term provincial supply picture.
- Produced right here in British Columbia providing jobs for British Columbians.
- [illegible] controlled here in British Columbia.
- [illegible] in its natural state - little refining.
- Moves through economic and secure pipeline transportation.
- Reduction in gasoline and propane imports provides an incentive for B.C. Government to keep NGV price advantage.
- Security of supply - not OPEC dependent.

NATURAL GAS - VEHICLE FUEL

Call it NGV [illegible]

PROMISE OF FUTURE DEVELOPMENT

Current research promises to [illegible] of these developments practical [illegible]

1. NGV [illegible] still used for ignition [illegible] research [illegible] power, less pollution, smoother operation and [illegible]
2. New computer [illegible] and more convenient self-service [illegible]
3. Very [illegible] can be made much [illegible] capacity can be increased. Aluminum and [illegible] may be superior tank materials.
4. Ford Motor Company is producing a limited number of light trucks with natural gas as the sole fuel for [illegible] and testing.
5. Home filling compressors have been developed, and some types are being tested. They appear to be practical, but as yet uneconomic.

SAFETY...
A BIG FEATURE

Natural gas for vehicles has established an enviable worldwide safety record in use for over forty years in various parts of the world. NGV has four big safety advantages.

1 NGV is lighter than air. If it ever leaks, it rises and dissipates into the air. Gasoline and propane vapours puddle.

2 Natural gas requires a higher ignition temperature than gasoline or propane, which makes it more difficult to accidently ignite.

3 NGV storage cylinders are incredibly strong. A typical cylinder has walls ¾" thick of special seamless steel. NGV cylinders are very likely the most indestructible component in a converted motor vehicle.

4 Natural Gas is a non-toxic substance, gasoline vapours are highly suspected as toxic.

In forty years there has never been a recorded serious injury or death due to NGV in use in 500,000 vehicles worldwide.

TAXIS GO FOR IT

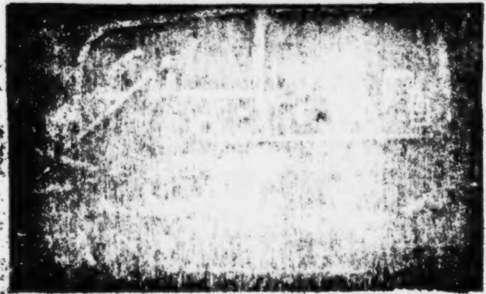
Taxi owners were among the first to go for the advantages of NGV. Taxis are subjected to tough stop and go city driving conditions and gasoline is a large operating expense. Some twenty Kamloops taxi cabs now run on natural gas. In Vancouver, Blacktop Cabs have converted their entire fleet. The Prince George taxi association has just put in its own NGV compressor and filling station.

Yellow and Kami Cabs fill at NGV pump.

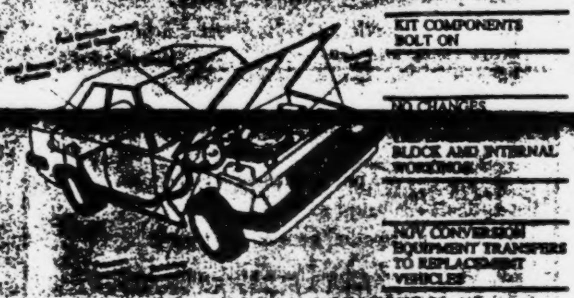
LONG HISTORY WORLDWIDE ACTIVITY

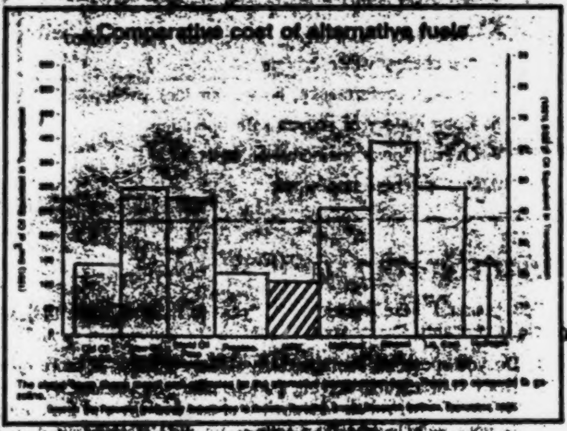
ITALY	The leading country in the world in the use of natural gas for vehicles. NGV has been in use since the early 1920's. Over 300,000 vehicles operate on NGV.
NEW ZEALAND	An ambitious plan is underway to convert 150,000 vehicles by the end of 1985. The country already has more than 130 filling stations.
U.S.A.	The number of NGV vehicles has more than doubled in the past three years alone. There are an estimated 75,000 vehicles now running on NGV. Environmental concerns and need for energy security are helping to bring about the change.
RUSSIA	A substantial plan exists to convert all Moscow taxis and buses to run on natural gas by 1987.
MEXICO	Officials are seriously interested in potential very large scale use of NGV. The displaced crude oil would be available for export revenue providing much needed foreign currency.
AUSTRALIA	Strong conversion activity is underway. A dual fuel diesel/natural gas heavy transport truck was recently displayed at the Perth Motor Show.
EUROPE	The use of NGV for transportation needs has been widespread for a good many years.

NGV vehicle pictured after participation in P.N.E. Demolition Derby. NGV fuel tanks are safe and sturdy.



D6 'CAT' rolls over NGV cylinder. Cylinder remained intact. Other fuel tanks were demolished.


KIT COMPONENTS BOLT ON
NO CHANGES
BLOCK AND INTERNAL WORKINGS
NGV CONVERSION EQUIPMENT TRANSFERS TO REPLACEMENT VEHICLES

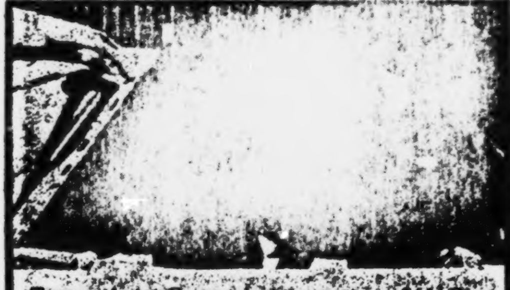


Comparative cost of alternative fuels

DRIVERS FIT ALL CATEGORIES

A partial list of Kamloops NGV drivers includes: contractors, homemakers, driver/salesmen, courier drivers, commutors, caterers, cab drivers, surveyors, sales representatives, mine workers, managers, fork truck operators, police officers, foresters, public works employees, florists, garage owners and many others.

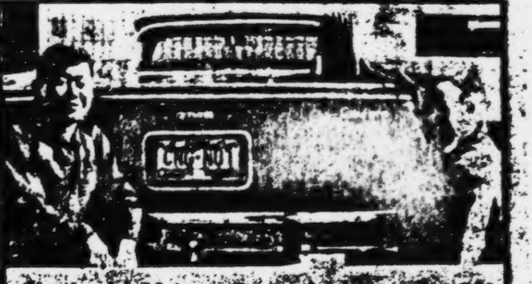
HOW TO CONVERT TO NGV



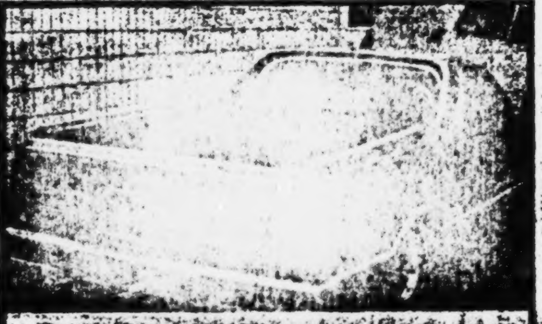
Towne Auto Conversion team — 844 West Columbia St.

CONVERSION TEAMS AT TWO LOCATIONS

Pictured on the left are brothers, Harold and Len Neufeld of Towne Automotive. On the right are Warren Goldney and Aki Ryujin of Northsyde Motors Ltd. Both shops are fully licenced to perform NGV conversions and have all the required training, equipment and installation experience required.



Northsyde Motors Conversion Team — 150 Larkspur Ave.



One very smooth NGV powered [illegible] [illegible]

CONVERSION BASICS

- A federal government conversion grant of $500. is available for any vehicle conversion. There is an additional $200. provincial government grant for non-commercial conversions.
- A typical two cylinder standard conversion of a private vehicle costs about $1350. after grants. A single cylinder conversion of a small car can cost as little as $900. after grants.
- All conversions are dual fuel, allowing you, by the flick of a switch, to still run your vehicle on gasoline when necessary. There are no significant changes made to your vehicle's engine, and there is no effect on insurance coverage or on your vehicle's warranty.
- The conversion equipment is designed to have a long service life, and it can be easily transferred later on to a replacement vehicle.
- There are no special maintenance requirements for NGV vehicles.
- Before conversion, a vehicle's engine must be in acceptable mechanical condition.

[illegible]

1. One half the price of regular gasoline.
2. Equal equivalent miles per gallon.
3. Oil and plugs stay cleaner, last longer.
4. Cuts exhaust emissions way down to help clean up the environment.
5. Excellent cold weather performance.
6. Dual fuel flexibility — more total fuel carried, can change while driving.
7. Smooth performance, no vapour lock ever.
8. Long history of proven safe operation.
9. Overall lower maintenance costs.
10. Fuel pilferage impossible.

NATURAL GAS
CONVERSION CENTRE

Conversion Centre open at Towne Auto on Columbia St.

IS IT FOR YOU?

Ask yourself these questions. A "yes" to most of them indicates that your vehicle is probably a very good candidate for conversion to NGV.

1. Do you spend an average thirty dollars a week or more on gasoline?
2. Does your regular driving pattern take you reasonably near the NGV filling station at The Sahali Mohawk Station, McGill and Columbia.
3. Is your vehicle less than four years old? If older, it may be suitable if the vehicle is in good mechanical condition.
4. Is a majority of your driving done within a 75 mile radius of our city? Note: dual fuel vehicles can fall back on gasoline for longer or out of the way trips.
5. Does your vehicle have space for NGV fuel cylinders? By far the majority of vehicles can carry cylinders in one way or another. Even very small vehicles can accommodate a single cylinder and that's often all they need. But, check this detail out first with a certified conversion mechanic.

OBTAIN MORE DETAILED INFORMATION ABOUT CONVERTING

* * * * *

Inland Natural Gas and Mohawk Oil Co. jointly announced their plans to open a Natural Auto Gas station in Kamloops before year end. This will be the first station for the B.C. Interior.

* * * * *

A Toyota diesel powered pick-up truck and a Toyota gasoline powered pick-up truck which had been converted to dual fuel Natural Auto Gas were on display at the 1983 Model Toyota Show held at the Vancouver Hyatt Regency Hotel

* * * * *

THE NATURAL ALTERNATIVE TO GASOLINE

AT

HALF THE COST

OBTAIN THE FACTS FROM: METHANE ENERGY DEVELOPMENT 873-3887

the daily sentinel, thursday, october 28, 1982

City gets CNG first

By MIKE KING
Daily Staff Reporter

Kamloops will have the Interior's first public compressed natural gas refuelling station, Inland Natural Gas Co. Ltd. officials announced today.

Ray Nadeau, Inland's regional manager in Kamloops, said the "fast-fill, full capacity" refuelling station isn't only a first for the Interior but a first for a public utility company in British Columbia.

The refuelling station, to be located at the Mohawk Oil Services centre at 884 Columbia Street West, is expected to be completed by early January, said Philip Murray, the local project engineer.

Cost of installing the necessary compressor is estimated at $330,000.

Once operational, Murray said that the price of compressed natural gas (CNG) will be "very competitive with propane and diesel fuels."

He said motorists using CNG can expect to save between 40 and 50 per cent "relative to gasoline fuel purchases".

CNG at the new station will retail at 24 cents for the equivalent of a litre of gasoline. The gasoline equivalent for propane is currently 34 cents a litre while gasoline currently retails for 45 cents a litre.

Murray indicated that in the beginning CNG will be more practical for fleet operations in the Kamloops area than for individual motorists.

The cost of converting a vehicle to operate on CNG is approximately $1,800 and the average range of the vehicle using CNG is 180 to 200 kilometres. Non-commercial vehicles are eligible, however, for federal grants of up to $600 and provincial government grants of up to $200 for converting to CNG use.

Operating at 3,600 psi (pounds per square inch), the Mohawk station will be capable of filling a CNG automotive tank in four minutes and have the capacity to fill vehicles continually.

"We're expecting this will be the forerunner of more stations throughout the Interior," said Murray.

He added that the potential "has been there for quite some time" but that there was a lack of proper facilities and initiative.

SEMINAR FEATURES

Complete Component Display

You will be able to examine all the components for conversion, first hand.

Natural Gas Powered Vehicles

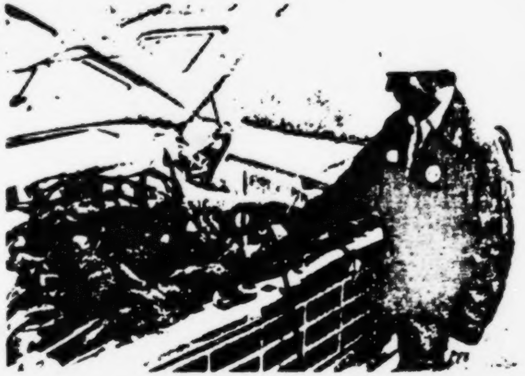
On display will be a vehicle from the Ministry of Universities and Science, Province of B.C.

Inland's natural gas powered HALF TON TRUCK

C.N.G. Fuel System's natural gas powered VAN

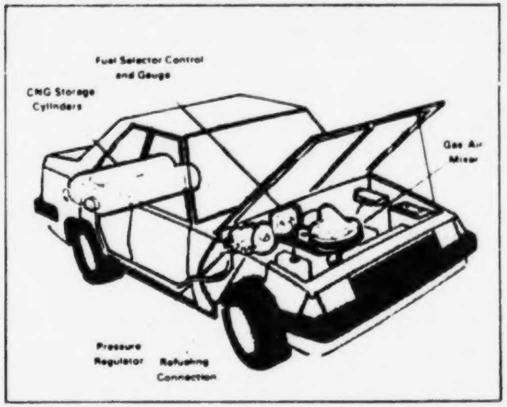
Displays

You will view the Provincial Government's twelve foot display on natural gas vehicle fuel, together with graphs on natural gas supply and costs.



CNG
NATURAL
ALTERNATIVE
GASOLINE

Seminar on Conversion to Natural Gas


Fuel Selector Control and Gauge
CNG Storage Cylinders
Gas Air Mixer
Pressure Regulator
Refueling Connection

Wednesday,
November 24th
Stockman's Motor Inn
Kamloops

OUR OPPORTUNITY TO XAMINE ....

- Economics
- Mechanics
- Equipment

of compressed natural gas for vehicle use

---

articipants:

nland Natural Gas Co. Ltd.
ransport Canada
ethane Energy
Development
.N.G. Fuel Systems Ltd.
ohawk Oil Co. Ltd.

Program

9:00 A.M. — 9:30	Mix and Meet Coffee Reception
9:30 — 10:00	Introduction to C.N.G. and future supplies by Bruce Vernon, Inland Natural Gas Co. Ltd.
10:00 — 10:15	Coffee
10:15 — 11:00	C.N.G. in British Columbia Gordon Pettigrew, Airport Branch Transport Canada George Lees, Methane Energy Development
11:00 — 11:30	Mechanics of Conversion Peter Gray, C.N.G. Fuel Systems Ltd.
11:30 — 12:00	Economics of Fleet Operation on Natural Gas Phillip Murray & Frank Dwyer, Inland Natural Gas Co. Ltd.
12:00 — 1:00 P.M.	Lunch Video tape presentation on natural gas vehicle fuel Warren Jennings, Inland Natural Gas Co. Ltd.
1:00 — ?	Hands on demonstration of equipment and vehicles

* * * * * * * * * *

Owners Report On Natural Gas Powered Vehicles

"I have been in the mechanical contracting business in Kamloops for 19 years and am proud to say that my vehicle was the first converted to natural gas in the Interor of B.C. back in February of 1982.

I get a range of about 220 kilometers or 140 miles on a fill up running exclusively on natural gas, with a 45% savings over gasoline.

We may be adding another vehicle in the future as my son has recently joined me in business. You can be sure that when we do, we will be running on natural gas."

OTTO FISCHER — President
Kamloops Mechanical Contractors

FOR MORE INFORMATION ON CONVERSION COSTS, GOVERNMENT GRANTS, AND INSTALLATION REQUIREMENTS, CONTACT TOWNE AUTOMOTIVE SERVICE AND REPAIR AT 844 WEST COLUMBIA ST. OR INLAND NATURAL GAS TODAY.

Owners Report On Natural Gas Powered Vehicles

BILL PHILLIPS — Yellow Cab

"I've been saving in the vicinity of $550.00 per month since I switched my cab to natural gas 28,000 miles ago, and in a business like mine, fuel costs are crucial.

The cab runs smoother and low maintenance has kept my cab working, instead of in the garage. I need to change the oil now, but the spark plugs that were installed at the time I converted are showing little sign of wear. That really impressed me.

I know that people are generally nervous about doing something new, but I can tell you that my cab has been performing better than the day I bought it, and fuel savings speak for themselves."

FOR MORE INFORMATION ON CONVERSION COSTS, GOVERNMENT GRANTS, AND INSTALLATION REQUIREMENTS, CONTACT TOWNE AUTOMOTIVE SERVICE AND REPAIR AT 844 WEST COLUMBIA ST. OR INLAND NATURAL GAS TODAY.

FUEL OF THE FUTURE

Compressed natural gas (CNG) is being heralded as the fuel of the future.

While gasoline is getting costlier and increasingly scarce, much of the world supply lies in the hands of a few nations (some of questionable political stability) and Canada's own oil reserves are inadequate to meet our needs, it's time for a viable alternative.

Fortunately British Columbia sits atop the answer — natural gas.

In June the Ministry of Energy, Mines and Petroleum Resources released a report by Dr. George Govier who studied the potential of natural gas in B.C.

Govier's report, Commissioner Inquiry on British Columbia's Requirements, Supply and Surplus of Natural Gas and Natural Gas Liquids, investigated the natural gas potential during the next 30 years.

Some of Govier's findings include: B.C. has an estimated ultimate potential of 500 billion cubic metres in the northeast fields alone; B.C. has discovered less than half of its potential supply so far: the province has used less than 20 per cent of its potential so far; proven reserves total 300 billion cubic metres; the province's current estimated surplus of marketable natural gas is 60 billion cubic metres.

Former Energy Minister Bob McClelland's response to the report was: "We've got areas right here — in B.C., Alberta and Saskatchewan — which have not yet been explored to anywhere near their full extent . . . that's where our emphasis should be. So, as a province, we've got to do that."

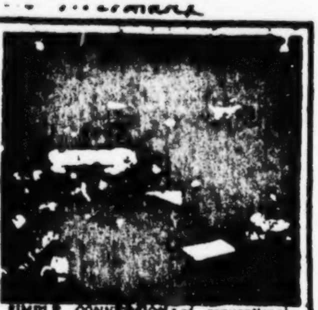
According to the Ministry of Universities, Science and Communications, besides the usual natural gas wells, the gas is found by some resource companies when they bring in an oil well.

The ministry noted that, until recently, natural gas was burned off by these companies to get it out of the way.

Natural gas, a fossil fuel in gas rather than liquid form, comes from wells as does crude oil.

It is under pressure as it leaves the ground, but at low pressure, natural gas is too bulky to be stored in a car or truck. Compressed at higher pressures, however, the gas becomes an ideal fuel.

A provincial government booklet, CNG: The Natural Alternative to Gasoline, states that natural gas compressed to about 20 kilograms per metre "makes an excellent automotive fuel".



SIMPLE CONVERSIONS of conventional gasoline and diesel engines to operate on compressed natural gas allows motorists to save up to 30 per cent in fuel costs. Mirko Mircevic, owner-manager of Mini-Tune (Kamloops) Ltd. checks out a propane conversion kit, which is similar to the CNG conversion kit.

First CNG station 'a natural'

Kamloops could become the Interior's first compressed natural gas (CNG) refuelling outlet for consumers.

Ray Nadeau, Inland Natural Gas regional manager in Kamloops, says the company "hopes to have the first CNG station made available to the public".

Bill Becker, owner - manager of Gulf's Versatile Travel Centre on the West Trans Canada Highway, has been working with Inland for the past year to establish a CNG refuelling station at his truck stop-travel centre.

Given the recent downturn in the Canadian economy, Becker admitted he is "re-assessing" the idea and in the meantime is "very much watching what's happening politically" in the energy field.

Becker suggested that, "if changes are made to the national energy program, we may not need an alternate fuel".

Nadeau, however, is more confident of the future of CNG.

He noted that the Canadian Gas Association has set up a committee which is currently drafting national gas standards. "They want Canadian standards rather than provincial standards, said Nadeau.

Because of British Columbia's natural gas wealth, Nadeau stressed that it's in the best interest of "our province to look at the proponents of natural gas."

Burning CNG in automobiles isn't new. It has been done in other countries since as early as the 1930s.

CNG filling stations are common in Italy, Holland, France, the United Kingdom, the United States and Australia. New Zealand is currently undergoing a major conversion from dependency on imported oil to natural gas.

The Ministry of Universities, Science and Communications lists four safety advantages of CNG over gasoline or propane.

These features are: CNG is lighter than air, if it leaks it rises and dissipates; CNG takes a temperature of 7,000 degrees Celsius or better to ignite; CNG is less combustible; CNG storage tanks are built, by law, to hold extreme pressure.

Figures from the American Gas Association indicate that there weren't any gas fires or explosions in 30 rear-end collisions with CNG-equipped vehicles last year.

"In our opinion, natural gas is considerably safer than gas or propane," stressed Nadeau.

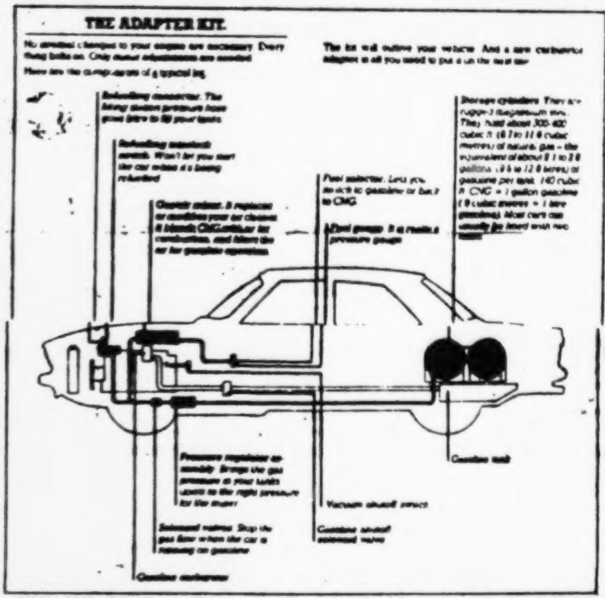
A major advantage of CNG use is the environmental effects.

It's estimated that CNG cuts pollution by 90 per cent compared with gasoline, according to provincial government tests.

Reports indicate that CNG burns more completely, more efficiently and cleaner. It doesn't contain any lead, doesn't produce particulate matter when burned and produces less carbon monoxide than gasoline.

Most importantly, it produces very little hydrcarbons that the sun can turn into smog, although it does need pollution control equipment to meet the nitrogen oxide emissions standards.

Reacting to the growing popularity of CNG, the Ford Motor Corporation has planned to design and manufacture automobiles to operate strictly on compressed natural gas.


THE ADAPTER KIT.
Refuelling connector.
Refuelling interlock switch.
Gas-air mixer.
Fuel selector. Lets you switch to gasoline or back to CNG
Fuel gauge. It is really a pressure gauge
Storage cylinders.
140 cubic ft CNG = 1 gallon gasoline
Gasoline tank
Pressure regulator assembly.
Vacuum shutoff switch
Solenoid valves.
Gasoline shutoff solenoid valve
Gasoline carburetor

HOW IT'S DONE — This diagram demonstrates how a compressed natural gas conversion kit operates with a conventional gasoline-burning automobile engine.

Convert and save 50 per cent

British Columbia motorists can save up to 50 per cent of their fuel costs by converting their vehicles to burn compressed natural gas (CNG).

Although the cost of a conversion kit is about $1,300, the long-term savings are attractive.

It takes about .9 cubic metres of natural gas to produce the same energy as a litre of gasoline.

Provincial government figures indicate that, at that ratio, natural gas can be expected to cost about half as much as regular gasoline purchased from B.C. service stations.

Based on current prices, the consumer cost of CNG is equivalent to 20 to 22 cents a litre of gasoline.

Ray Nadeau, Inland Natural Gas regional manager in Kamloops, noted that "supply and demand" of natural gas will dictate the future cost of CNG at the pumps.

Car and truck gasoline engines don't need any internal modifications to operate on CNG.

Conversion kits currently on the market store CNG, control its flow and mix it with air for combustion. Vehicles retain their gasoline tanks and original fuel systems. With the CNG conversion kit, vehicles are able to operate on both the gas and gasoline at the turn of a switch.

The kits don't have to stay with the vehicle. A change of carburetor adapters allows the kit to be added to a new or other vehicle.

Only four engine adjustments are necessary when converting a conventional gasoline or diesel engine to CNG.

First, the air cleaner may have to be replaced with the gas-air mixer included with the conversion kit.

Timing then has to be advanced five to 10 degrees beyond the vehicle manufacturer's specifications — up to 30 degrees before - top dead centre maximum (timing).

Spark plug gaps may also be reduced by about .010 to produce a better spark.

Finally, the inlet pressure must be adjusted so that the gas-air mixture contains between five and 15 per cent fuel.

Mechanics trained in CNG conversions take eight to 12 hours to install a kit.

College seeks top-up

Cariboo College wants to become the second institute in British Columbia to offer training in compressed natural gas (CNG) vehicle conversions.

The Lower Mainland's Pacific Vocational Institute currently offers the only CNG training in the province.

Les Batchelor, Cariboo's mechanical training department chairman, said the college is affected by the Pacific Vocational Institute's "provincial mandate to offer its courses".

Batchelor claimed that the provincial government "has created competition between Cariboo and PVI (Pacific Vocational Institute)" for funds and grants.

Availability of funds is the key stumbling block preventing Cariboo from establishing a CNG training centre, said Batchelor.

"We would have to compete for the funding" with the PVI," Batchelor explained. With recent cutbacks and implemented restraint programs, funds aren't readily available for new programs.

Batchelor indicated that the college can't even make a submission to the provincial government "until there is sufficient demand" for a new program.

The only exception, according to Batchelor, would be to offer CNG training through the college's Continuing Education program on a "fee-for-service basis".

In this case, Batchelor noted that most of the cost "would have to be borne by customers' wanting their vehicles converted to operate on CNG.

Students of Continuing Education "work strictly on demand," Batchelor said.

"If the demand is sufficient we can respond to it" and offer CNG training, assured Batchelor.

Art Meger, mechanical department instructor, said "once companies in the Kamloops area want to register their mechanics (in CNG converting), there will be pressure on the college to offer a program".

Meger has completed the PVI program and is now registered with the Gas Fitters of B.C.

His certification makes him one of the few people in Kamloops properly trained in CNG conversion.

Because of the high pressures involved in compressing natural gas, Meger said it's necessary to have Gas Fitters of B.C. certification and standards.

Meger would be responsible for heading a college-based CNG training centre. "I could handle the program myself," said Meger.

In the meantime, Batchelor stressed how the college "would sure like to do something" and get involved in the growing field of CNG conversions.

STORIES
and
PHOTO
by
MIKE KING

CNG fuel of the present

Kamloops Daily Oct. 29/82

By MIKE KING
Daily Staff Reporter

The RCMP is investigating it, Cariboo College is studying it and [illegible]low Cabs may soon [illegible]ch to it.

Compressed natural gas (CNG) came one step closer to reality as an alternative fuel in British Columbia's Interior Thursday.

Inland Natural Gas Ltd. and the Mohawk Oil Co. jointly announced the upcoming opening of the firstpublic CNG refueling station in the Interior. It will be located at the Mohawk Oil Services station at 884 Columbia Street West and is expected to be operational by the first of the year.

Phillip Murray, Inland's local project engineer, stated two main reasons for locating a CNG refueling station in Kamloops.

"There's a good industrial b[illegible] with many commercial fl[illegible]s and a sincere desire and interest for a (CNG) centre here," said Phillip.

Don O'Connor, a senior spokesman for Mohawk, said CNG "meets our criteria for superior motor fuel performance at a lower co to the public."

Murray said Inland an Mohawk hope "to keep (price of CNG) at about ha the price of gasoline."

Sgt. Luke Mulder, of th Kamloops RCM Subdivision said the feder. and provincial governmen are talking about convertin police fleets to CNG.

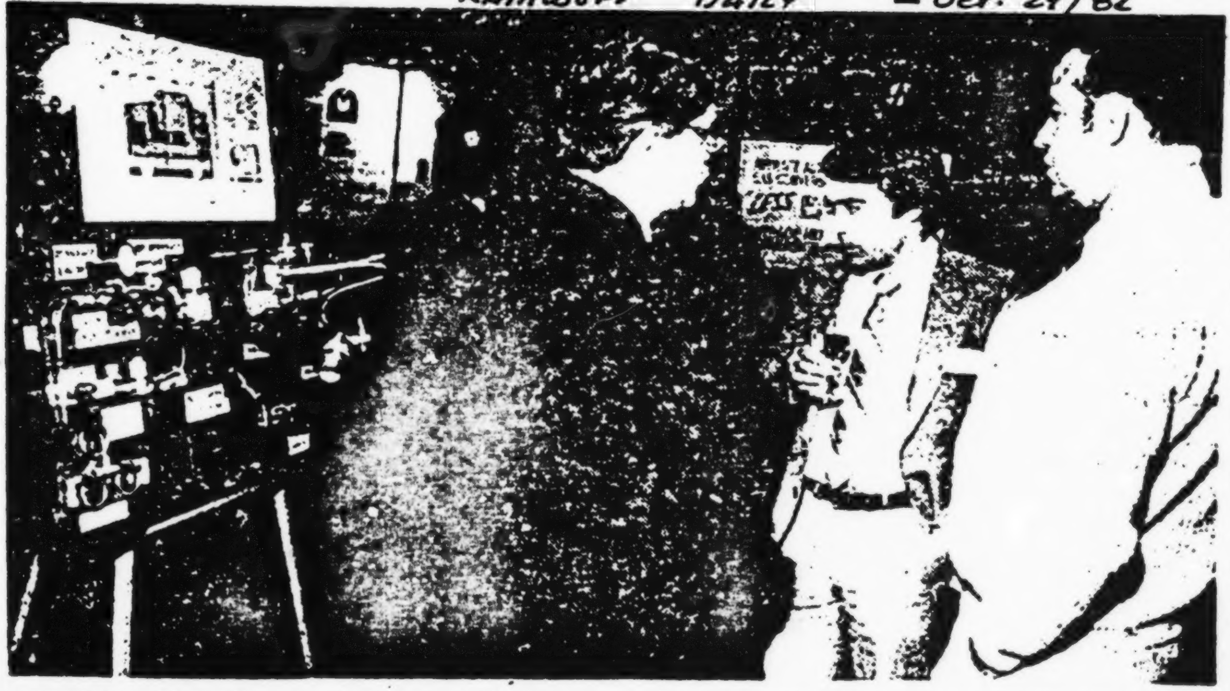
Mulder stressed that CN would have to prove to b cost effective befor conversions would begin.

Mayor Mike Latt guaranteed that "the cit will look very long and hard at the idea of converting th city's fleet to natural gas.

Cariboo College ha already expressed a interest in offering a cours to licenced mechanics i conversions.

Bill Phillips, manager c Yellow Cabs Ltd., has "toye with the idea" of acquiring compressor to service hi taxis for the past year.

"I anticipate that withi two or three months afte Mohawk opens (CN service) at least six of m cabs will be converted," sai Phillips.



EYEING THE FUTURE, one guest at a press conference to announce a new compressed natural gas public refueling station in Kamloops checks over the components of a conversion kit while talking to a representative from Inland Natural Gas.

Mike King Photo

inland natural gas salutes a winner

Inland Natural Gas welcomes Prestige Parcel Ltd., operator of Greyhound Parcel Express, to the growing number of progressive businesses who now use economical natural gas to power their vehicles.

Greyhound Parcel Express Vans now running on Natural Gas

- changing today
to serve you better tomorrow.

Prestige Parcel Ltd. manager Garry Clermont has converted three in his fleet of fast delivery vans to use natural gas vehicle fuel. Under the Greyhound Parcel Express banner, these efficient units offer fast local parcel delivery as well as bus pickup and delivery. A new service, in association with Air Canada, provides overnight service from Kamloops to key cities in all of Canada and the Eastern United States.

Progressive businessmen like Garry Clermont are making the decision to switch to natural gas because of the dollar saving benefits. Natural gas is far less expensive than gasoline or other alternatives. Downtime for maintenance is reduced. It's a safe and abundant fuel, and best of all we produce it here in B.C.

FOR MORE INFORMATION CONTACT INLAND NATURAL GAS CO. LTD.
374-8121

Natural Gas Vehicle Fuel. The future belongs to the efficient.

INLAND FIRST WITH CNG IN INTERIOR

The first facility of its kind in the B.C. Interior is under construction in Kamloops....a compressed natural gas refuelling centre.

An official announcement was made in December by Inland Natural Gas Co. Ltd. that the $330,000 installation will be at the Mohawk Oil service station on the corner of McGill Road and West Columbia Street, Kamloops.

Only one cng retail outlet is currently dispensing the fuel in British Columbia and that is Jim Cunningham Service, West 70th Avenue, Vancouver.

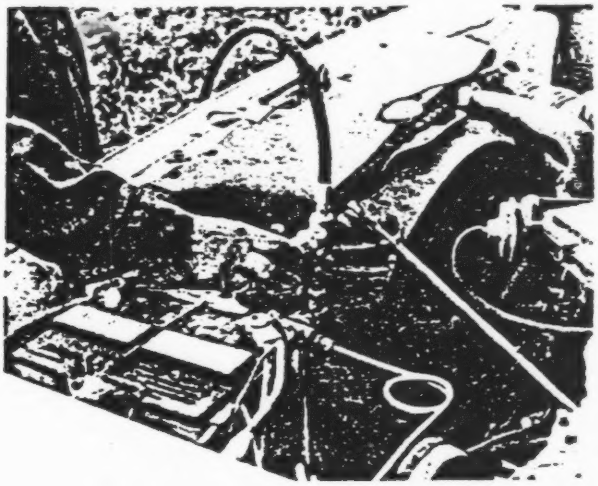
Bruce Vernon of Inland Natural Gas said the construction start followed almost a year of technical and financial studies.

Local project engineer, Phillip Murray, said the pricing of cng as an automotive fuel would be very competitive with propane and diesel and users could expect to realize savings of 40 to 50 per cent relative to gasoline purchases.

CNG will retail at the Kamloops facility for the equivalent of gasoline at 24c per litre. The gasoline equivalent for propane is now 34c per litre.

Murray pointed out, however, that the cost of converting vehicles (while partially government subsidized) combined with an average range of 180 to 200 kilometres per fill up would make cng more practical for fleets operating in the Kamloops district than for individual vehicle owners.

Vernon said Inland will be monitoring public and fleet response to the acceptability of cng very closely with a view to the possibility of assisting in the development of further refuelling outlets in other Interior centres if sufficient response is established.



Compressed natural gas refuelling will take approximately four minutes at Inland's new cng facility in Kamloops. Gas is pressurized to 3,000 psi providing a range of 180/200 kilometres. CNG conversion kits cost about $1,800 installed but non-commercial vehicles are eligible for a $600 federal grant and $200 Provincial. The pay back can be from 2 to 3 years for private vehicles and less than six months for some fleet vehicles. A flip of a switch allows an operator to utilize either natural gas or gasoline in this dual-fuel system.

Don Stuart and Don O'Connor, senior personnel with Mohawk Oil Co., said that they welcomed their association with Inland in developing the Kamloops cng centre.

Stuart said Mohawk views the development of any automotive fuel alternative which would be to the public's benefit as a positive step.

A FIRST

Many people visited the Interior's first public compressed natural gas (CNG) refuelling station at its grand opening last week. Some checked out converted vehicles (above) while others spoke to representatives of Inland Natural Gas and the Mohawk Oil Company. Officials from both comanies hope the Kamloops station will be the first of many CNG stations in the Interior.

Daily Staff Photo

CITY OF KAMLOOPS NEWSLETTER.

CITYSCENE

MARCH ISSUE

Truck purrs at price from the past

Inland's Frank Dwyer goes over the new system with (left to right), Louis Grande, Stan Jackson, Stan Schneider, driver George Coakes and Brian Zeck.

10 cents a litre.

If it wasn't for metric, it would sound like a price from the '50s. Yet on February 23, 1983, the City began an experiment with Compressed Natural Gas (CNG) that potentially could cut the cost of fuelling city vehicles by as much as 75 per cent.

Inland Natural Gas spokesman Frank Dwyer, who was down at the Public Works Yard recently to train mechanics and drivers on the new fuel system which has been installed on one City truck, said that although CNG retails for about half the cost of an equivalent litre of gasoline, the City could buy the product in bulk for as little as 10½ cents a litre.

Another advantage to natural gas is that it can cut maintenance of vehicles by up to 50 per cent by doubling the interval between oil changes and spark plug replacement as well as giving an average engine a life of up to 250,000 miles.

Not to be confused with propane – which puddles if it leaks – CNG is lighter than air and ignites at a much higher temperature than gasoline. A lit cigarette wouldn't touch it off.

And as another bonus, CNG reduces exhaust emissions by 90 per cent, starts the vehicles easier in cold and makes for smoother idling in hot weather.

There are, however, a couple of drawbacks. Even with the government grant it costs about $1400 to convert a vehicle to CNG and the range of an average vehicle, because of the relatively large size of the tanks required, is usually only 160 kilometres per fill up. The City test truck, and all other vehicles adapted to CNG, has a crossover switch which allows the driver to use regular gasoline without even turning off the engine.

The CNG experiment is only one measure the City is taking to reduce the cost of running its vehicles. We're also testing a synthetic oil which requires changing only once every 100,000 miles.

We'll give you the results of both tests in a future edition of Cityscene.

J. TOUHEY

NEWSPAPER
→ Clippings fil

Natural gas conversion proposed for district school buses

By GAIL FARRAR

Discussion on the use of natural gas as a vehicle fuel sparked debate last weekend over whether school buses should be on the front lines of vehicle conversion programs.

A week ago, provincial Universities Minister Pat McGeer chaired a meeting in Williams Lake to promote the use of compressed natural gas as a vehicle fuel.

In this district, he said, converting the 90 school buses to operate on natural gas would save a maximum of $1000 a day.

School District 27 Transportation Superintendent Elton Elliott expressed skepticism at the idea of converting school buses to the fuel.

He said the Kamloops school district last year converted six school buses to operate on compressed natural gas, and had "nothing but trouble with them – to the point where they converted them all back to gasoline.

He said there were always two buses out of commission at any one time with component problems.

And a serious accident was narrowly avoided when one bus quit in the middle of the road with a tractor trailer unit coming each way.

McGeer said it is possible to do a bad job of installation but the bus should not have been in jeopardy. During the changeover period, he said, all vehicles would be equipped with gasoline and natural gas tanks. All the driver needs to do is flip a button and the bus would run on gasoline.

Jack Touhey, a representative of Inland Natural Gas, said the Kamloops school district took on the project at a time when Inland didn't have a conversion specialists working in the area.

He said the company has learned from that mistake and now has a conversion specialist assigned to the area. It is also more careful about which lower-powered vehicles are converted to use compressed natural gas.

It was noted that there are a fleet of 15 natural-gas-powered school buses in Terrace and another 50 in Ontario.

McGeer said it is government policy to convert government vehicles to natural gas where compressed natural gas outlets exist.

"I don't think government would force a school district to convert but we would certainly ask some penetrating questions if they didn't when the savings are so obvious," he said.

"But I can also see the point that it is a learning process and we must go slow at first to avoid mistakes such as ones made in Kamloops."

"I think it is a mistake to rely on one source of information where a job was done poorly," McGeer said.

He said he has driven five natural gas-powered vehicles and none of the problems associated with their operation are serious. It is just a matter of "pulling ourselves up by our bootstraps mechanically."

He stressed the importance of involving bus drivers in the learning process about natural gas conversions, and the importance of bringing the vehic[illegible] i check-up when things ap be wrong.

Kamloops named centre for CNG fuel program

ALLAN McRAE
porter, The News

it's another first for Kam-
ps.

The city has been chosen as
site for the first compressed
tural gas auto refueling sta-
n in the B.C. interior.

Inland Natural Gas and Mo-
wk Oil Canada Ltd. announc-
Thursday that a $330,000 re-
lling centre is to be installed
the site of the present Mo-
wk service station at the cor-
r of Columbia Street and
Gill Road.

Spokesmen for the two firms were on hand at a press conference in Kamloops where they outlined some of the highlights of natural gas as a motor fuel alternative.

Phillip Murray, project engineer for Inland in Kamloops, said this community was choosen as the first interior site because of the high number of commercial fleets operating locally.

Murray said the current plan, which calls for the centre to be opened in late December, initially for 16 hours daily, will see CNG selling for about 24 cents per litre. Murray pointed out that because natural gas is not a liquid the volume mentioned is equivalent to a litre of gas.

He compared the price of CNG to propane at 28 to 34 cents and gasoline at about 45 cents per litre.

Murray said conversions must still be to dual fuel options-CNG and gasoline.

There are several reasons for this. The driving range of CNG tanks is not great enough to allow for long distance driving. Refueling stations are still few and far between.

"It is still more suited to fleet operations" where vehicles can return to home base frequently for refueling, said Murray.

He pointed out that CNG has been used for years in Italy and, in the past few years, in New Zealand where the fuel has proven to be both economical and safe.

The cost of converting a vehcile to CNG is normally about $1,800, said Inland project head Bruce Murray. However that may rise more as lighter aluminum tanks are employed to store the CNG.

Vernon pointed out the federal government is offering a $600 grant toward the cost of conversion. The province offers a $200 grant to non-commercial car owners and drops all social service tax charges on the purchase of equipment used to install the system in a vehicle.

In a film shown during the press conference it was pointed out that cost savings for a fleet using 110 delivery vans will be about $176,000 per year when energy prices climb higher several years from now.

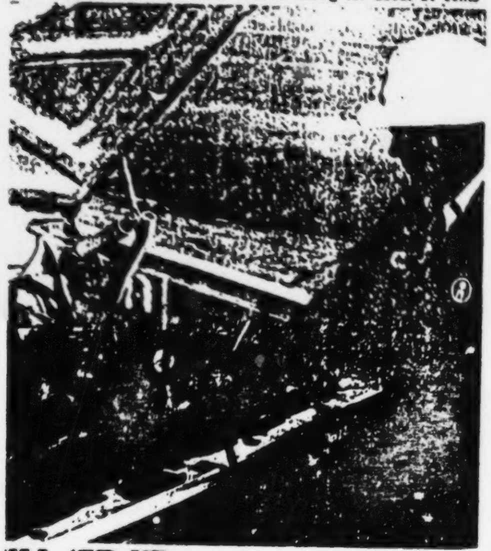
To prepare for the demand, plans are being set up by the two firms to offer conversion and related skills programs.

Mohawk spokesman Don O'Connor said his firm has been experimenting with a number of alternate fuels over the past few years. Among these are propane, gasohol and CNG.

He said Mohawk is also interested in the use of methane and coal conversion as auto fuels.

One of the big advantages of CNG is that its supply is virtually unlimited. Until a few years ago most natural gas was burned off at the wellhead as it was considered a nuisance in the pumping of crude oil.

Vernon pointed out that CNG could take over the total gasoline market in the province and still have a large surplus left over.



ILL 'ER UP. *Compressed natural gas refuelling
ll take about four minutes at the interior's first compres-
d natural gas facility. Gas is pressurized to 3,000 PSI pro-
ding a range of 180-200 kilometres.*

City will take a look at CNG conversion

he City of Kam-
s plans to look se-
sly into convert-
part of its fleet of
icles to compres-
natural gas.

layor Mike Latta,
attended a press
ference Thursday
on by Inland Nat-
l Gas and Mohawk
on the opening of
NG service station
Kamloops, said the
will study the
ility of using the
in its vehicles.

Assistant City administrator Pat Anderson said later that the City now has tenders out for a couple of propane fueled vehicles, but that CNG appears to be an even more viable option now that there is service station in Kamloops.

"The City will be seriously looking at it," said Anderson. He added that it might be best to test both alternate fuels to see what is best for Kamloops.